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ON CRETACEOUS PITYOXYLA.[1]

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(WITH PLATES I AND II)

IN a recent publication Dr. ARTHUR HOLLICK[2] has described the discovery of amber in the Raritan formation of the Middle Cretaceous, at Kreischerville, Staten Island. The amber in question occurs in largest quantity "in a stratum or bed, characterized by layers and closely packed masses of vegetable débris, consisting of leaves, twigs, and fragments of lignite and charred wood." Lignite occurring in association with amber at Cape Sable, Magothy River, Anne Arundel County, Maryland, collected by Professor A. BIBBINS of the Woman's College, Baltimore, and of somewhat similar geological horizon, has recently been determined by Dr. F. H. KNOWLTON[3] of the United States Geological Survey as a new species of Cupressinoxylon. It appeared desirable to one of us that the lignites associated with the Kreischerville deposits of amber should be subjected to microscopic examination, in view of the possibility that the succiniferous ones might also turn out to belong to an extinct species of Sequoia (Cupressinoxylon). On communicating with Dr. HOLLICK in regard to this possibility, he very kindly consented to a combined visit to the beds at Kreischerville, for the purpose of securing authentic specimens of the succiniferous and other lignites. On April 18, 1905, we examined together the various

[1] Contributions from the Phanerogamic Laboratories of Harvard University, No. 5.

[2] Amer. Nat. **39**:137–145. 1905. Contributions from the New York Botanical Garden, No. 64.

[3] American amber-producing tree. Science N. S. **3**:582–584. *figs. 1–4.* 1896.

excavations in the Cretaceous clays at Kreischerville, particularly that known as the Androvette pit, where the largest quantities of amber have been found. We were fortunate enough on this occasion to secure a large quantity of lignites, including several fragments of some size, showing the amber *in situ*. On a subsequent visit, in the following autumn a further supply of material was secured, including some admirably preserved Pityoxylon from a newly opened excavation known as the Drummond pit.

The lignites gathered at Kreischerville belong to at least three genera: Araucarioxylon, Cupressinoxylon, and Pityoxylon. Of these only the last proved to be succiniferous. The first two genera mentioned represent several species and present features of very considerable interest, but it is not our intention to discuss them further here. The pityoxyloid lignite containing masses of amber was found in the form of large pieces from the various excavations at Kreischerville, as well as in smaller fragments occurring in the amber-bearing strata themselves, at the Androvette pit, as described by Dr. HOLLICK (*l. c.*). The amber enclosed in lignite appears both in the translucent shining condition and in the dull ochraceous modification. In the latter state it is particularly conspicuous on account of the contrast in color with the black lignite, and may be made out not only in the form of pockets and nuggets, but also as fine yellow threads or streaks corresponding to the normal resin passages of the wood. Unfortunately the state of preservation of most of the succiniferous lignites left something to be desired. In the Drummond and Androvette pits, however, were found a number of partially charred, and, as a consequence, exquisitely preserved Pityoxyla, which were apparently specifically identical with or at any rate closely allied to the actually succiniferous fragments of Pityoxylon. It has been thought advisable to defer the description of the amber-containing lignites until a greater quantity of material should be accumulated, which might not only be better preserved, but might also throw some light on the conditions leading to the formation of amber. The partially charred lignites belonging to the genus *Pityoxylon* Kraus appear, nevertheless, worthy of immediate investigation, both because they show features of considerable phylogenetic interest, and because the genus Pity-

oxylon is considered by some paleobotanists not to antedate the Tertiary.[4]

The specimens of Pityoxylon, which have served as the material for the present investigation, consist for the most part of cylindrical fragments, which are sometimes as thick as 10^{cm} and often twice as long. Most of them however are of smaller size. Where the pieces are cylindrical they generally include the pith in a good state of preservation, a feature of some importance in connection with their diagnosis. It is not possible to state absolutely from the nature of the specimens whether they represent smaller branches or merely the core of larger axes from which the external layers have been burned off. From the ordinarily tylosed condition of the resin canals, it may be inferred with a strong degree of probability that the latter supposition is more likely to be correct. Angular fragments showing annual rings with a large radius of curvature permit a study of the structure of the older wood. Although at least two different species of fascicles of pine needles and at least as many species of cone scales of Pinus, all in an admirable condition of preservation, have been found in association with the Pityoxyla from the Androvette pit, it has not been possible to distinguish in these lignites more than one type of wood structure. The material in this respect presents an interesting parallel to the condition found by CONWENTZ[5] to exist in the Pityoxyla of the Eocene or early Oligocene, which bear the well-known Baltic amber; for this author declares that he is unable in the vast variety of fossil succiniferous woods which have passed under his inspection to diagnose more than a single species. The absence of clearly marked criteria for the separation of species on the basis of wood structure is not surprising, since even in the case of living pines it is difficult to do more than segregate the various species into larger groups or sections on the characters offered by the wood.

Fig. 1 shows the structural features of a transverse section of a slightly flattened branch about 5^{cm} in thickness in its greatest diameter, and showing more or less distinctly about twenty annual

[4] *Cf.* GOTHAN, Zur Anatomie lebender u. fossiler Gymnospermen-Hölzer 88. Herausgeb. von der Königlich Preussischen Geologischen Landesanstalt und Bergakademie. pp. 108. Berlin, 1905.

[5] Monographie der Baltischen Bernsteinbäume. Danzig, 1890.

rings. It is to be observed from the photograph that the annual rings are not as strongly marked as they are in pines of the present day. This feature is due to the less pronounced thickening of the tracheids of the summer wood. There are no parenchyma cells present in the wood except those which surround the resin canals. The rays are strongly marked on account of the resinous character of their contents, a feature of difference from modern pines, where as a rule the ray-cells are quite free from the dark brown secretion which is characteristic of the resiniferous cells in the Cupressineae and in the genera Cedrus and Tsuga among the Abietineae. The resin canals show a tendency to become aggregated in clusters. They may be almost absent in one or more annual rings and correspondingly abundant in others. The resin ducts are surrounded by highly resiniferous cells and appear not to be confined to any special region of the annual ring. On the left of the figure is to be seen a resin canal occluded by tyloses.

Fig. 2 shows a section of the same branch which includes a portion of the pith. The medullary cells are filled with dark brown contents. Sclerified cells are quite absent in the pith. To the right of the photograph a process passes off from the medulla, which is the pith of a small branch, in all probability a brachyblast or short shoot. In the wood immediately adjoining the pith may be seen a number of resin canals, closely filled with tyloses. The position of these resin canals in relation to the pith is that found among living species of Pinus, in the hard pines (*Sclerophitys* auct.), in which the resin canals also abut on the pith, in some cases actually occurring in the primary wood, in contrast to the soft pines (*Malacophitys* auct.), where the resin ducts are somewhat remote from the pith and never occur in the primary wood. The annual rings are generally less well marked in proximity to the medulla than in the more external part of the wood.

Fig. 3 is a longitudinal radial view of the wood of the same specimen illustrated in the two preceding photographs. The section shows a single vertical and several anastomosing horizontal resin canals, all quite filled with tyloses. A careful inspection indicates that the wood is made up of tracheids, which are provided with a single vertical row of radial bordered pits.

Fig. 4 shows the structure of the wood in the same specimen, as seen in tangential section under a low magnification. The rays are of the two kinds found in *Pityoxylon* Kraus, namely, linear and fusiform.

Fig. 5 shows a tangential view of part of the same section, more highly magnified. In this view the radial pits of the tracheids may be seen in profile, and on the left a face view of a few tangential pits. In some of the rays dark contents may be made out in the cells, which have partially shrunk away from walls. This is apparently of the same nature as the dark brown material found in the resin cells of certain living conifers. The interesting fact to be noted is that the resin occurs equally in the marginal and in the central cells of the ray. This feature may be clearly distinguished in two of the rays on the lower left portion of the photograph. In living pines resin never occurs in the marginal cells of the ray, which, as is well known, are not true parenchymatous cells, but are of a tracheary nature. They are in fact variously described as marginal tracheids, horizontal tracheids, and tracheidal cells.

Fig. 6 shows another portion of the same section as that represented in *fig. 4*, on the same scale of magnification as *fig. 5*. This figure shows very clearly the occurrence of tangential pits, which are confined to the autumnal tracheids as in certain living species of Pinus. In *figs. 5* and *6* may be seen fusiform rays containing horizontal resin canals occluded by tyloses.

Fig. 7 represents a transverse section, under high power of magnification, of the autumnal wood of a specimen showing annual rings with a large radius of curvature. The elements are much larger in this instance, as is the rule in the older wood of the Coniferales in general. The tangential pits of the autumnal wood can be very clearly made out. We have found no specimen of Pityoxylon from the Kreischerville deposits in which the tangential pitting of the autumnal tracheids is not a marked feature. CONWENTZ has pointed out that this feature is also present in the autumnal wood of the Baltic amber-producing trees (*l. c.*, p. 21).

It will be inferred from the above description that the Cretaceous Pityoxyla just described differ in several features from the woods of any modern or even Tertiary species of Pinus. The leafy short-

shoots found in intimate association with the Pityoxylon here described, which unquestionably belong to the genus Pinus in the narrower sense, have the double bundle which is characteristic of the hard pines,[6] as has been learned by one of us from a microscopic investigation of their structure. They are also provided with the persistent foliar sheaths, which are a striking feature of the hard or pitch pines in contrast to the soft pines, which have deciduous sheaths. All the numerous cone scales found in intimate association with the wood, illustrated in our *figs. 1–7*, are equally characteristic of the hard pines, for they have the thickened apophysis and median umbo, which are unfailing features of that group. In the case of our Pityoxylon, however, we find universally present the tangential pits of the autumnal tracheids, which are characteristic of the existing soft pines.[7] STRASBURGER, however, states that he has found tangential pits to be present in the autumnal wood of *Pinus canariensis* and *Pinus rigida*. MAYR[8] has also called attention to the occasional occurrence of tangential pits in the autumnal wood of one group of the hard pines. This feature has also not escaped the notice of CONWENTZ. One of us has observed the very frequent occurrence of tangential pits in the autumnal wood of the *cone* in various species of hard pines, where they are quite absent in the vegetative wood. This is the case, for example, in the woody axis of the cone of *P. Pinaster*, the vegetative wood of which is described by KRAUS[9] as having no tangential pits. *P. palustris* too, although it is a characteristic hard pine, in the absence of tangential pits from its autumnal wood,[10] possesses these in great abundance in the autumnal wood of its cone, in both the annual rings present. These two examples will suffice to illustrate the fact that tangential autumnal pits, such as are ordinarily absent in the wood of hard pines, are generally present in their *cones*. It may be inferred from the mode of their occurrence that tangential

[6] COULTER and ROSE, Synopsis of North American pines based on leaf-anatomy. BOT. GAZETTE 11:256, 302. 1886.

[7] PENHALLOW, Anatomy of the Coniferales. Amer. Nat. **38**:243. 1904. STRASBURGER, Ueber den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen.

[8] Waldungen Nordamerikas.

[9] Beiträge zur Kenntniss fossiler Hölzer, p. 25.

[10] PENHALLOW, *loc. cit.*, :04.

bordered pits in the tracheids of the hard pines are an ancestral feature. It is accordingly not surprising to find them more commonly present in older types of hard pines than those now living. CONWENTZ in his admirably accurate and thorough account of the wood of *Pinus succinifera* notes their invariable presence in this species, which on account of its denticulate marginal ray-tracheids must be considered to belong to the hard pines. As has already been pointed out, the structure of the associated leaf fascicles and cone scales leads to the conclusion that the Cretaceous Pityoxylon under discussion belongs also to a hard pine. The mode of occurrence of the resin canals in the medullary crown, which is illustrated in *fig. 2*, is also that which is characteristic of the hard pines.

The most reliable feature of difference separating histologically the hard pines from the soft pines is the occurrence of denticulate marginal tracheids in the former group. In the soft pines the marginal tracheids are entirely without denticulations. In our Pityoxylon, as has been shown above, marginal tracheids of any kind are quite absent; so that it is not possible on this feature to diagnose the affinity of our material with either of the two main groups of pines still living. It is of interest to note that the Cretaceous Pityoxylon under discussion has the general structure of the rays found in Abies or Pseudolarix, with the wood structure found in Tertiary and modern species of Pinus. There can be little doubt that in the peculiar structure of the rays we have to do with an ancestral feature; for if we take for example a modern species of Pinus, in which the marginal tracheids are well developed even in the first annual ring, such as *P. palustris*, we find the marginal tracheary cells entirely absent in most of the rays of the two annual rings of the female cone. It is well known that in many of the modern species of Pinus the marginal tracheary ray-cells do not appear until the branch is from one to several years old. The same feature, if one may judge from CONWENTZ' description, was also present to an even more marked degree in the Baltic amber pines, which are considered by CONWENTZ to belong to the early Oligocene or late Eocene. Another feature of striking resemblance presented by the wood of the *cones* only of existing species of Pinus, to the vegetative woods of Cretaceous Pityoxyla which we have investigated, is the highly

resinous character of the ray-cells. This feature may also be well seen in *P. palustris*, already referred to. The contrast in the contents of the ray-cells as they occur in the wood of the cone or of a vegetative branch is very strongly marked.

It may be inferred that we have overlooked the presence of tracheary marginal cells in the Cretaceous Pityoxyla, which are the subject of the present article. This view cannot however be accepted, as the wood of some of our partially charred specimens is in a perfect condition of preservation, often not even showing the spiral striations which are generally found as a feature of decay in many fossil woods, otherwise well preserved. Moreover, in shallow rays consisting of a single stratum of cells, which in the case of modern species of Pinus are composed entirely of tracheids, the cells are parenchymatous and invariably filled with a dark brown resinous content, which leaves no doubt as to their histological nature. The cells on the margins of the rays in our Pityoxylon are moreover related to the central cells of the rays and to each other by simple pits and not by bordered pits, as is the case with the marginal tracheids. It is obvious that the ray-structure of Pinus underwent a great change in the passage from the Mesozoic to the Tertiary period.

On account of the geographical occurrence of the Pityoxylon, which has just been described, it is called **Pityoxylon statenense.** The diagnosis is as follows:

Transverse.—Annual rings narrow, sometimes not clearly marked; wood parenchyma absent except in the periphery of the resin canals, which may occur in any part of the annual rings and are often stopped with tyloses; rays highly resinous; bordered pits present on the tangential walls of the autumnal tracheids; tracheids about 25 μ in diameter.

Radial.—Radial pits of tracheids about 17 μ in diameter, in a single vertical row, round with a round mouth; pits of the ray-cells about one per tracheid, round or somewhat elliptical, 10 μ in diameter; ray-cells all parenchymatous, very resinous, length from 100 to 120 μ; marginal ray tracheids quite absent.

Tangential.—Rays of two kinds, linear and fusiform, the latter containing resin canals which are surrounded with rather thick-walled parenchyma; resin canals often occluded by tyloses; tangential pits present in the autumn wood.

In addition to the Pityoxylon described above, we have examined another of the same type, which was secured by Dr. ISAAC BOWMAN

from a newly exposed section at Third Cliff, Scituate, Mass. Although there is some question as to the exact geological age of the strata from which it was taken, it is considered desirable to refer to it at the present time on account of the interesting similarity to the species discussed above. DR. BOWMAN describes[11] the section from which the material was taken as follows: "The section at Third Cliff shows yellow clays at the base conformably overlain by yellow and white sands and succeeded by a bed of bright red sands with an unconformity at their base. On the eroded edges of the red and white beds are deposited dark glauconitic and lignitic clays and sands. The entire series of beds has a total maximum thickness of 60 or 70 feet and outcrops for half a mile along the cliff face. Absolutely no erratic material occurs either within the beds themselves or along the lines of unconformity." The lignite to be described came from the "lignitic sands and clays" just mentioned.

The material consisted originally of several laminated and badly preserved fragments, together with one larger piece, cubical and about 12^{cm} in its three dimensions. The better-preserved fragment has served as the basis of the following description. As the result of decay and pressure, the lignite has suffered some compression both in the radial and tangential planes. The stress in the radial plane has produced a considerable sinuosity in the course of the wood rays. The annual rings cannot be made out with the naked eye or even with a pocket lens of some degree of magnification.

Fig. 8 shows a magnified portion of a transverse section of this wood. The area of the photograph includes parts of two annual rings. The line of demarcation is very indistinct and runs obliquely a little above the lower third of the photograph. The rays are very dark on account of the highly resinous character of their contents. Two large patches of parenchyma may be seen surrounding two vertical resin canals. The large amount of resiniferous parenchyma about the canals is particularly characteristic of this species. There are no parenchyma cells in the wood other than those surrounding the resin canals. The annual rings have a very slight radius of curvature and are somewhat distorted on account of the compression of the wood, although the elements which compose them are well

[11] Science N. S. **22**:993–994. 1905.

preserved. The lignite under discussion obviously is part of an old stem.

Fig. 9 is a radial view of the wood of the Pityoxylon from the cliffs at Scituate. This view shows the extremely resinous character of the rays, which doubtless is largely responsible for the good preservation of the wood, as, unlike the material of *Pityoxylon statenense*, it has not been charred in any way by fire. The rays are quite without tracheidal marginal cells and in this respect resemble those of the first described species, and differ from the ray vegetative structure found in any modern species of Pinus.

Fig. 10 shows a tangential view of the wood. The rays are obviously of two kinds, namely, linear and fusiform. The former are often very deep, and in this feature present a marked contrast to the first described species of Pityoxylon. The fusiform rays are usually occupied by a horizontal resin canal, the lumen of which is often filled with a dark brown material similar to that found in the surrounding resiniferous cells of the ray. Tyloses have not been found either in the horizontal or the vertical resin canals of this species.

Fig. 11 shows a portion of the same section more highly magnified. The highly resinous character of the rays can clearly be made out. There is one fusiform ray present containing a horizontal resin canal, which is filled with a dark brown material similar to that found in the ray-cells. It may here be stated that in spite of the fact that the cells surrounding the lumina of the horizontal and vertical resin ducts cannot be described accurately as being thick-walled, nevertheless the ducts are never occupied by tyloses.

Fig. 12 shows another tangential view under considerable magnification. This illustrates the fact that in the rays the marginal as well as the central cells contain the same dark brown resin, as has already been referred to in the case of the other Cretaceous Pityoxylon described above. The wood is so well preserved that there can be no question as to the absence of marginal tracheids, such as occur in the rays of living species of Pinus and allied genera. Not only are the marginal cells filled with the same dark resinous material as the other cells of the ray, but they are related radially to each other, as well as to the central cells of the ray, above and below by simple pits.

This species of Pityoxylon is named **Pityoxylon scituatense,** from its place of origin. The diagnosis is as follows:

Transverse.—Annual rings moderately broad, indistinctly marked; resin ducts present, surrounded by a very deep zone of resiniferous parenchyma, without tyloses but sometimes filled with dark resinous contents; wood parenchyma quite absent; rays very dark and resinous; tracheids averaging 39 μ in diameter.

Radial.—Radial pits of the tracheids in a single row with the very oblique narrow mouths forming a cross, diameter of the pits about 20 μ; pits of the ray-cells generally one per tracheid with narrow oblique mouth, about 10 μ in diameter; ray-cells all parenchymatous, average length 340 μ, very resinous; marginal ray-tracheids quite absent.

Tangential.—Rays of two kinds, linear and fusiform, the former often very deep; fusiform rays containing horizontal resin canals, which are always free from tyloses although somewhat thin-walled, both kinds of rays very resinous; tangential pits present in some of the tracheids.

In the two species of Pityoxylon described above, we have to do with woods which resemble those of the existing pines, but which nevertheless differ from them in important particulars. The marginal ray tracheids, which are not only characteristic of Pinus but of the allied genera Picea, Pseudotsuga, and Larix, are quite absent in our two species. The question arises whether it is proper to include them within the genus Pityoxylon, which has recently been stated not to antedate the Tertiary.[12] There is much to be said for such a course. In the case of our *Pityoxylon statenense* there can be no reasonable doubt that we have to do with the wood of a fossil species of Pinus, from the abundant occurrence in intimate association with the lignites of charred remains of cone scales and leaf fascicles of pines. Any doubt as to the identity of these scales and foliar shoots has been removed by a study of their microscopic structure, as well as their external features. Further, one of us has observed from the study of the *cones* of living pines that the features which are characteristic of our fossil woods are exactly those which are found to be distinctive of the wood structure of the cones of the living species of Pinus. There can be little doubt that in the case of the wood of the cones of *Pinus palustris*, for example, the general absence of marginal tracheids, the highly resinous character of the rays, and the abundant presence of tan-

[12] GOTHAN, *l. c.*, p. 88.

gential autumnal pits, all features of difference from the vegetative wood structure of existing hard pines, are ancestral characters, since such characters are wont to linger on in the reproductive axis. Indeed in no other way can the presence of these features in the wood of the cone be explained. It seems inadvisable to invent a new generic name for a fossil wood, which although lacking the marginal ray tracheids, which are characteristic not only of the wood of living pines, but of also Pityoxylon as generally defined, is beyond any reasonable doubt the wood of a Cretaceous pine. We find it difficult to follow GOTHAN (*l. c.*, p. 102) in establishing a new pityoxyloid genus of fossil woods, Pinuxylon, to which is assigned the ligneous characters of the living Pinus in the narrower sense. *Pityoxylon* Kraus seems rather in need of a wider than a narrower interpretation, if it is to include the wood of Pinus of the Cretaceous as well as Tertiary times. In the case of our *Pityoxylon statenense* there can be no reasonable doubt that we have to do with the wood of an extinct Cretaceous pine. It seems on account of its distinctive archaic features, however, inadvisable to name it under Pinus as CONWENTZ has rightly done in the case of the Tertiary *Pinus succinifera*, which is practically identical in its wood structure with modern hard pines. The retention of the genus *Pityoxylon* Kraus appears, for the present at any rate, absolutely essential in view of such cases as that presented by our *Pityoxylon statenense*. The evidence as to *Pityoxylon scituatense* is much less clear, as no cone scales or leaves have been found with it. Since, however, it presents the same general features as *P. statenense*, it may conveniently be included under the same genus.

There is good reason to believe from recent researches[13] that the genus Pinus in essentially its modern form, so far as the external features of the female cones go, existed as far back as the Jurassic. There is even evidence that the two great series of the hard and soft pines existed at this early period so that the geological extension of the genus must have been much more remote. Without considering the evidence for the existence of Abietineae at earlier geological periods than the Tertiary, furnished by impressions of the

[13] FLICHE, P. et ZEILLER, R., Florule portlandienne des environs de Boulogne-sur-Mer. Bull. Soc. Géol. France IV. 4:787–812. 1904.

foliage, etc., there are now definite records, based on internal structure, which carry the group far into the past. KNOWLTON[14] has recently described an abietineous wood from the Jurassic beds of the Black Hills of Dakota which he calls *Pinoxylon dacotense*. It is characterized by the possession of vertical resin canals only, which are numerous and may occur in any part of the clearly marked annual rings. The structure of the tracheids and rays is that of the Abietineae. This author does not mention the presence of marginal ray tracheids, and in view of the fact that he describes the wood as admirably preserved, they probably may be considered to be absent here as in our Cretaceous Pityoxyla.

The *Pityoxylon Conwentzianum* of GOEPPERT from the Carboniferous of Waldenburg,[15] which has often been called in question, has received full confirmation from the description of a similar type of Pityoxylon, *P. chasense*, by PENHALLOW[16] from the Permian of Kansas. In these two species vertical resin canals are said to be absent, although the horizontal canals of the fusiform rays are clearly present. There is, accordingly, every reason to believe that the Abietineae are a very ancient group in their first appearance. In fact, they may be traced geologically quite as far back as the Araucarineae, which it is customary at the present time to regard as the oldest of the Coniferales. That they are not more numerously represented in the Mesozoic and earlier strata is probably entirely a matter of antisepsis, since araucarineous remains are in general much better preserved than are those of the Abietineae, where they are found imbedded together in the same strata. Mention need not be made here of the *Pityoxylon eggense* (Witham) Kraus and *Pityoxylon Hollicki* Knowlton,[17] since both of these appear to have been in a bad state of preservation.

The peculiar structure of the wood of Pinus in the Cretaceous, as distinguished from that found in the case of Tertiary and living pines, probably affords an explanation of the greater vigor of the

[14] U. S. Geol. Surv. Ann. Rept. **20**[2]: 420–422. 1898–1899.

[15] GOEPPERT, Revision meiner Arbeiten.

[16] North American species of Dadoxylon. Trans. Roy. Soc. Canada II. **6**[4]: 76. 1900.

[17] Trans. N. Y. Acad. Sci. **16**: 134–136.

genus under modern conditions. It is generally inferred that genera which flourish under modern conditions cannot be of very ancient origin. This generalization, however, cannot be accepted in the case of Pinus, which, although found actually abundantly throughout the northern hemisphere in from 80 to 90 species, can be traced in obviously allied genera back to the Carboniferous. The appearance of marginal ray tracheids about the beginning of the Tertiary epoch, with the resulting improvement of water-supply, in all probability explains why so comparatively large-leaved a conifer should have been able not only to live on into the modern period, but to flourish as it never had before. Even at the comparatively early epoch of the Baltic amber beds (probably Eocene), there were numerous species present in the somewhat restricted area represented by that formation.

CONCLUSIONS.

1. The woods of certain pines of the Middle Cretaceous of Staten Island differed from those of existing pines (*a*) in the absence of marginal tracheids in the rays; (*b*) in the highly resinous nature of the rays; (*c*) in the association of characteristic features of the hard pines, as exemplified by leaf-fascicles, cone-scales, and structure of the primary wood, with the numerous tangential pits of the autumnal wood which are a feature of the living soft pines.

2. These features of difference from modern pines are probably to be regarded as ancestral, since they persist clearly and strongly in the structure of the wood of the cones of the living species.

3. The appearance of marginal tracheids in the rays of Pinus is comparatively modern and does not in all probability antedate the Tertiary. It probably explains the greater prosperity of the genus in recent times.

4. Another species of Pityoxylon from Scituate, Mass., has been described, which has the general features of the Pityoxyla of Staten Island. It is not possible, however, to refer it definitely to Pinus, nor is its geological horizon settled.

In conclusion we wish to offer our warm thanks to Dr. HOLLICK for many kindnesses in the matter of securing material.

HARVARD UNIVERSITY.

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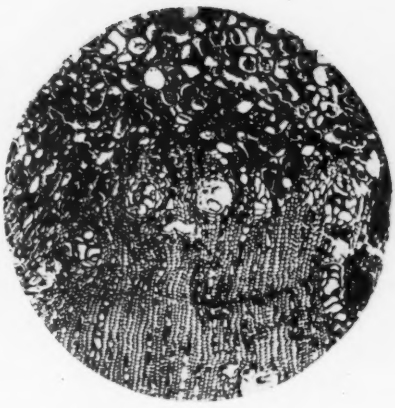

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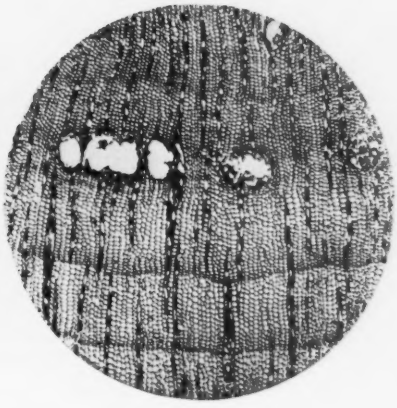

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JEFFREY & CHRYSLER on PITYOXYLA

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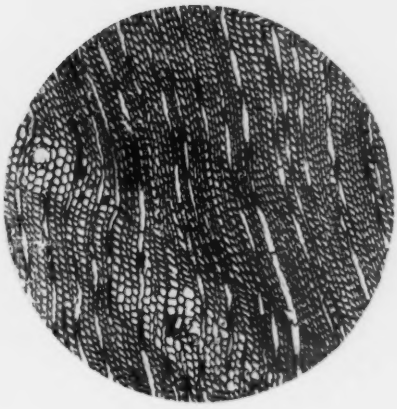

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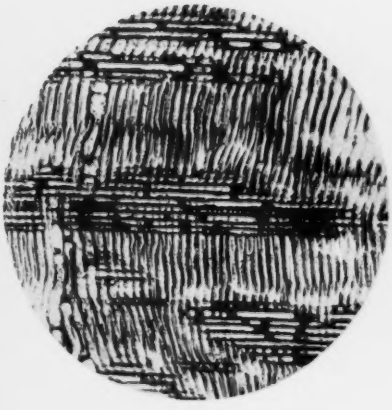

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JEFFREY & CHRYSLER on PITYOXYLA

EXPLANATION OF PLATES I AND II.

PLATE I.

Pityoxylon staleneuse.

FIG. 1. Transverse section of the wood. ×20.
FIG. 2. Transverse section of the wood near the pith. ×40.
FIG. 3. Radial section. ×60.
FIG. 4. Tangential section. ×60.
FIG. 5. Tangential section. ×180.
FIG. 6. Tangential section. ×180.

PLATE II.

FIG. 7. Transverse section. ×200.

Pityoxylon scituatense.

FIG. 8. Transverse section. ×60.
FIG. 9. Radial section. ×30.
FIG. 10. Tangential section. ×60.
FIG. 11. Tangential section. ×180.
FIG. 12. Tangential section. ×180.

A STUDY OF THE VEGETATION OF THE MESA REGION EAST OF PIKE'S PEAK: THE BOUTELOUA FORMATION.

I. STRUCTURE OF THE FORMATION.

H. L. SHANTZ.

(WITH MAP AND SEVEN FIGURES)

THE region under consideration in this study lies at the base of Pike's Peak and north and west of Colorado Springs. It is the portion known as the Mesa and the Garden of the Gods and contains 3200 to 4000 hectares (*map*). While my attention has been confined largely to this region, studies have been pushed out in all directions, and I have attempted to make myself familiar with the mountain and plains conditions of vegetation, as well as that of the area under consideration. Especial attention was given to the plains which extend eastward from the area first studied.

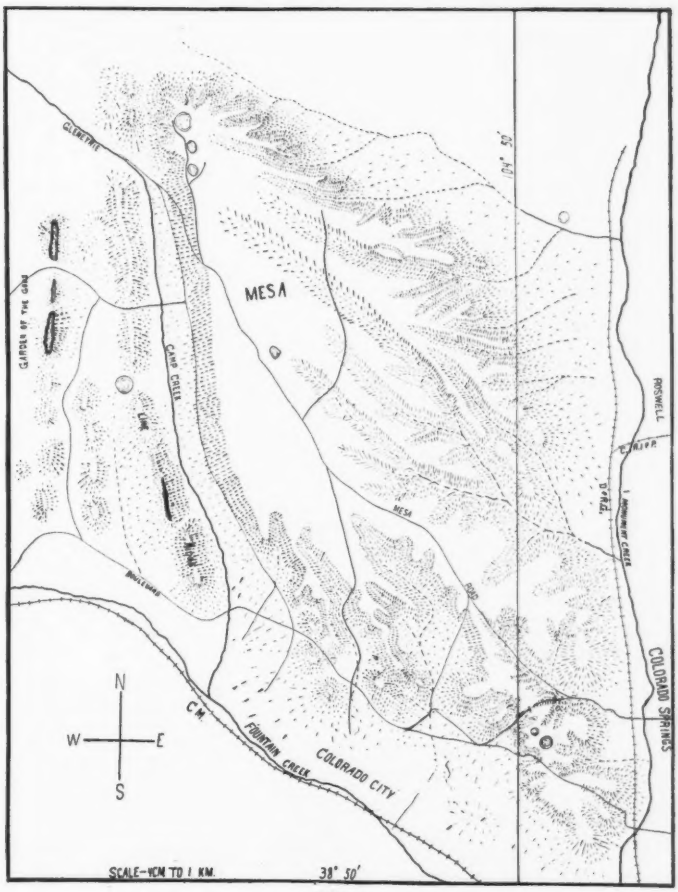
METHODS.

The methods used in the study of the structure and development of the vegetation, as well as in the study of the physical factors, are those used by CLEMENTS[1] in his ecological studies and need not be mentioned here. The exact methods have been supplemented by careful field notes and photographs. The greatest care was exercised in physical factor readings. The soil samples for the determination of water content were taken with a soil borer, which gave a column of soil reaching to a depth of 15^{cm} and about 2^{cm} in diameter.

Relative humidity readings were taken as near as possible to the surface, and also one meter above. A constant record of relative humidity was obtained by means of the hygrometer at Colorado City, and the isolated readings were compared with this record as well as with the record of the United States Weather Bureau at Colorado Springs. Temperature readings were taken in the soil

[1] CLEMENTS, F. S., Research methods in ecology. Univ. Pub. Co., Lincoln, Neb. 1905.

at a depth of 15^{cm}, at the surface of the soil, on the plant, at 10^{cm} above the soil, and finally 1^{m} above the surface. A constant record was taken by means of a thermograph, and the records of the Weather Bureau were also made use of to check the results thus obtained.



MAP.

In the measurement of light the writer has used the ordinary photometric method, but has used the standard derived from the candle power. Solio paper was exposed to a standard candle for

15 hours at a distance of 10^{cm}. The Hefner-Alteneck lamp burning acetate of amyl was used as a standard. The diameter of the wick was 8^{mm} and the height of the flame was 40^{mm}. The shade produced on the Solio paper was used as a standard and copied in permanent colors. Strips of the same sheet of Solio used to make the standard were exposed and the time required to produce the standard tint recorded. This gave mathematical data and a very simple means of comparing light intensities. The light at the June solstice was about 4.5 seconds. All exposures were made parallel to the soil surface.

In the diagnosis of the habitat I have given the figures found to apply during the time studied. Rainfall, temperature, wind, and humidity are averaged for four seasons. The data in water content are based on a single season's work, but on a great many readings. The data on non-available water were obtained by taking the soil samples at the time when the plants were dying. This water varies not only with the species, but also with the individual plants. The data as collected were largely at the time of the dying of *Boebera papposa*, *Salvia lanceolata*, *Helianthus annuus*, *Verbesina encelioides*, and *Solanum rostratum*, mostly during the latter part of the aestival period; and these results are given in the other diagnoses, since at other times it was impossible under natural conditions to obtain such data. Available water is expressed in grams to 100 grams of dry soil. The duration of each aspect, as well as many of the factors which are definitely stated, varies from year to year.

The species lists are arranged to give an idea of the relative importance of the species under each heading, the most important species appearing first. The lists without the species in parentheses are for the Mesa region only. Important species of the formation which do not occur in the Mesa region are included in parentheses. They will be taken up under the general discussion. In the lists important parasitic fungi always appear after the species upon which they occur.

Within the formation the following are the terms applied to the plant associations: *consocies*, or areas which are dominated by a facies of the formation and which at all periods give the character-

istic stamp to the vegetation; *societies*, or minor divisions, characterized by principal species and dominant usually over smaller areas and only during the aspect in which they occur; *communities*, or smaller associations, usually of secondary species.

GEOLOGY.

The eastern base of the Rocky Mountains shows a great many rock systems which are upturned and all come to the surface in or near this region. Lying on the Archean granite, which forms the mountains at the west, is found a Cambrian red sandstone, gravel or lime. The Silurian or Manitou limestone lies next, followed by the reddish gray quartzite sandstone of the Carboniferous. East of this the Garden of the Gods is formed by the great red sandstone outcrop which is placed in the Permian or in the Triassic—authorities differ. The Jurassic, which lies next, is followed by the Cretaceous rock system, represented by the following epochs. The lowest is of the Dakota—the white sandstone ridge or hogback, and the great sandstone ledges. Lying next and buried in most places under the talus of the latter is the Benton shale. The most eastern of the series of hogbacks marks the outcrop of the Niobrara limestone. The Fort Pierre shale is found in many places east of the lime ridge and underlies the whole Mesa region. Lying above this is found the recent Quaternary deposit of gravel of granitic origin.

The sedimentary deposits underlie the entire Great Plains region, but in most places are covered by the more recent wash from the mountains. For the geological development and structure of the Great Plains, as well as for a description of the topography and climate, the reader is referred to the exceedingly interesting publication by JOHNSON.[2] The following quotation from this source (p. 612) gives a very clear idea of the origin of the plains.

> The Great Plains are of such vast dimensions it is only in imagination that they can be regarded as a foot slope to the Rocky Mountains. However, in the sense that, superficially, ranging down to several hundred feet in depth, they have been built to a smooth surface by mountain waste, stream-spread to great distances, they have this character. At the base of the mountains the Plains mass has a thickness, to sea level, of several thousand feet. It is made up in

[2] JOHNSON, W. D., The high plains and their utilization. Ann. Rept. U. S. Geol. Survey 21[4]: 601–741. 1899–1900.

the main of marine-rock sheets with a general inclination eastward, due to broad regional tilting, in which the plains and mountains have shared together.

But the present surface grade of the Plains is not that of the original tilting. The surface has undergone a series of transformations. These have all been accomplished by the eastward-flowing streams from the mountains. In a first stage the mountain streams, traversing the Plains, cut into the smooth structural slope, and produced a topography of parallel broad valleys and ridges. In a second stage they ceased to cut, depositing instead, and refilling the valleys

FIG. 1.—Gully on the east side of the Mesa; alternation between thicket and grass formation.

they had excavated, even burying the intervening ridges, to a smooth upper surface. The original surface was a product of deformation, the second of a destructive process of stream erosion, the third a product of stream deposit and construction, involving the spreading of a waste sheet to great distances and a uniform level, and to a depth over the greater valleys often of several hundred feet. In the final and present stage, virtually the same streams have returned to the earlier destructive habit, and erosion has in large part carried away the high level plain of stream construction. About midway of the long slope, in the north-south irregular belt, large uneroded fragments of the smooth constructional plain remain. As we have seen above, these fragments constitute the High Plains.

PHYSIOGRAPHY AND SOILS.

The exposure of the Mesa is southeast, the grade being about 18^{m} to the km. The northwest portion, which is the highest, has an elevation of 1889^{m}. On the east and south sides of this Mesa the water has cut deep gullies (*fig. 1*), which appear older on the south than on the east, the slope being more gradual and the soil more stable. The east side of the Mesa is bounded by a low region largely of clay sand, which slopes gradually to Monument Creek. On the north side there is a less elevated region which, however, does not differ markedly from the Mesa itself. On the west side is Camp Creek, which has cut down into the Fort Pierre clay.

The soil of the Mesa is a gravel mixed with a limited amount of clay and humus. The gullies and edges of the Mesa are made up of Ft. Pierre clay, which is in places mixed to some extent with the Quaternary gravel which lies above it.

CLIMATE.

Rainfall.—The greatest amount of rain is during the growing season, the fall and winter, as a rule, receiving very little. As a result the vegetation is not protected in the least by snow during winter, nor is there a sufficient amount of water to retard the evaporation from the aerial parts of the plant. There is, as a rule, considerable rain during the summer months from May to September, but often the rainy season is much shorter, covering, as it did in 1903, only June, July, and August. The rainfall is about 32 to 43^{cm}, but because of the unequal distribution throughout the year, this affords a rather luxuriant summer growth. This seasonal variation in rainfall is best illustrated by the following table, which gives the rainfall in centimeters.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1901	0.15	0.17	2.97	4.67	9.52	....	....	5.68	5.58	1.24	0.02	0.45	.....
1902	0.20	0.35	1.01	2.07	13.28	3.96	4.21	6.83	3.40	0.38	0.05	0.55	33.29
1903	0.15	1.77	0.93	2.41	1.57	12.95	1.07	6.29	1.52	0.86	2.03	0.63	32.18
1904	0.27	0.48	0.15	0.58	10.46	9.86	7.87	6.35	5.25	0.67	Trace	1.14	43.08

There is also a daily variation in rainfall which is of some importance to the plant. The relative humidity, of course, is much higher during the night than it is during the day, and on this account rain

which falls in the afternoon and leaves the ground wet at night sinks into the soil and does the plant much more good than does that which is followed by a clear sky and rapid evaporation.

A study of the rainfall record shows that much more rain falls during the afternoon than during the forenoon. During the months of May, June, July, and August, 1904, 72 per cent. of the rain fell in the afternoon; while 71 per cent. of the hours during which rain was falling were in the afternoon. The sunshine record (*fig. 6*) also makes this plain.

Relative humidity.—A deposit of dew is extremely rare. The relative humidity therefore seldom reaches 100 per cent. except during showers. During the day it is generally low, often being as low as 1 per cent.; on account of this, rain or snow is soon evaporated. The relative humidity is especially low during winter when there is little rain and when during the day the temperature often rises to 16°–20° C. The following table gives the relative humidity for each month of the year 1904; and *fig. 2* illustrates the daily variation.

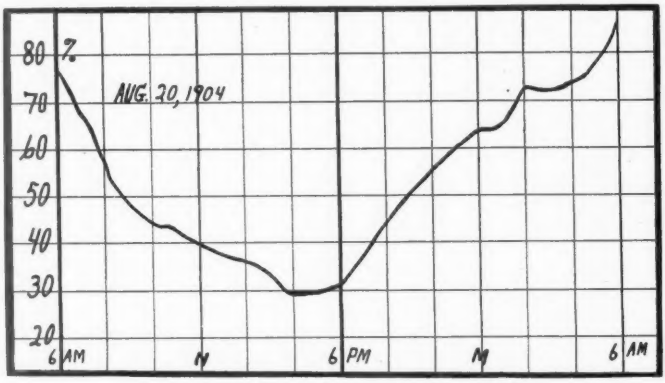


FIG. 2.—Daily variation in relative humidity.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum....	90	89	100	100	100	94	90	95	100	100	89	100
Minimum....	1	8	6	1	11	12	9	21	13	12	12	5
Average.....	47	41	42	44	55	54	51	55	44	52	43	49

Wind.—The chief importance of wind is its effect upon the transpiration of the plant and upon the water content of the soil. The

following are the velocities in hm. per hour for the different months of the year 1904: Jan. 4.6; Feb. 3.3; Mar. 5.7; Apr. 6.09; May 4.7; June 3.7; July 3.5; Aug. 3.2; Sept. 3.7; Oct. 3.8; Nov. 4.04; Dec. 4.3.

Temperature.—Extremes in temperature do not occur. The summer temperature is seldom above 32° C., and the winter temperature is seldom −18° C. The maximum temperature recorded during the four years 1901–4 was 36°.6 C., and the minimum for the same period −28°.3 C. The following temperatures are for the year 1904.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum.	17.7	21.6	20.5	22.8	25.5	28.3	31.6	29.4	28.3	23.3	19.3	18.8
Minimum.	−18.3	−18.3	−14.4	−9.4	−1.1	2.7	6.1	7.2	5.5	−5.5	−5.5	−20.5
Mean.....	− 2.8	2.2	3.9	7.7	11.5	14.9	18.2	19.5	17.3	9.4	5.1	0.2

The mean temperature is derived from the daily maximum and minimum. The daily variation may best be shown by curves from the thermograph (*fig. 3*).

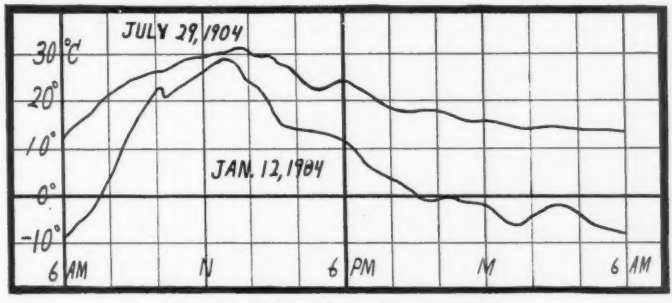


FIG. 3.—Daily variation in temperature.

A comparison of these curves will show clearly how much greater is the daily range in winter than in summer. The curve for January 12, 1901, rises higher than the typical winter curve, but is otherwise normal.

A series of curves showing the variation in temperature between the soil, soil surface, plant surface, 10^{cm} above the soil surface, and 1^{m} above will serve to show how different are the conditions of

temperature under which the plant lives from those ordinarily recorded (*fig. 4*). At the top of the figure is given the sunshine

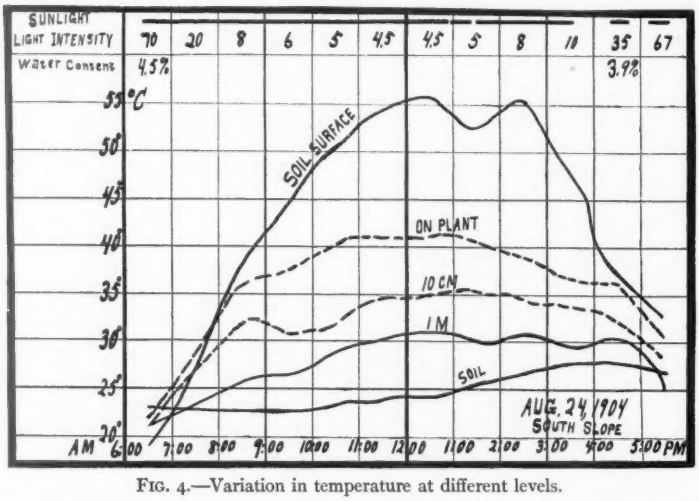


FIG. 4.—Variation in temperature at different levels.

record, together with the light intensity for each hour of the day. The water content was determined twice, as recorded in the figure. The plant surface temperature record was taken on a mat of *Bouteloua oligostachya*, and the quadrat was situated on a south slope.

The extreme conditions at the surface of the soil may account to some extent for the dying of the lower stem leaves, so often noted among perennials as well as annuals.

Simultaneous readings on north, south, east, and west slopes give the curves for soil and soil surface temperatures shown in *fig. 5*. The water content was recorded twice in each quadrat and is also given in the figure; curves of soil temperature are given at the bottom of the figure. Some idea of the temperature at the various levels may be obtained by comparing these curves with those of *fig. 4*. The readings shown by *figs. 4* and *5* are simultaneous.

Light.—The sunshine records taken show 51 to 80 per cent. of possible sunshine. The difference between possible sunshine for the forenoon and afternoon is seven to nine hours per month during

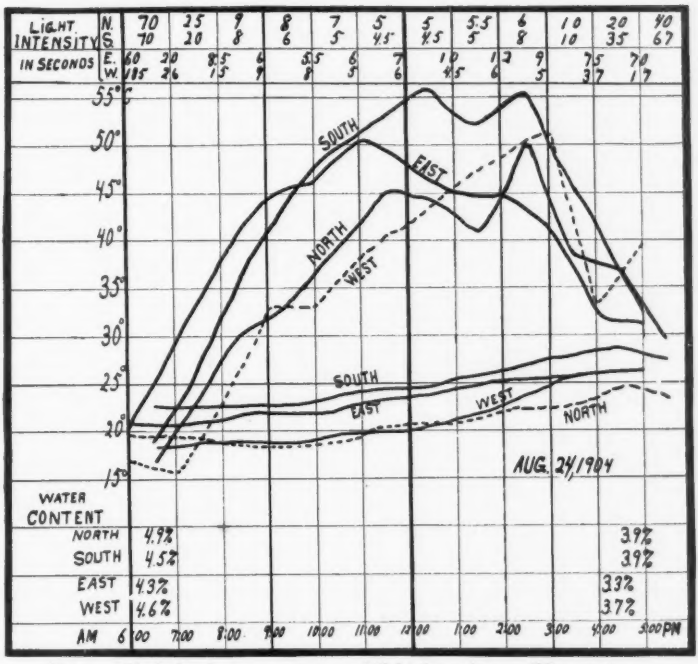


FIG. 5.—Variation in temperature and light intensity on different slopes.

the period of growth. This is due to the mountains which shorten the period of illumination for the afternoon. The rains and cloudy

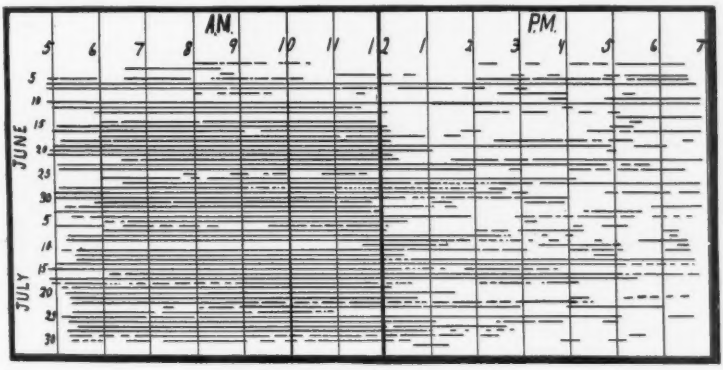


FIG. 6.—Sunshine record.

sky occur most frequently during the afternoon, which on this account also receives much less sun than does the forenoon. The record for sunshine for June and July 1904 makes this clear (*fig. 6*).

The difference in the light received by the east and west slopes, together with the resulting differences in temperature, relative humidity, and water content, is of importance in explaining the vegetation of these exposures.

The Bouteloua (grama grass) formation.

This formation occupies practically the whole Mesa region and the low land surrounding it. It extends for many miles north, south, and east, but no attempt has been made to determine its limits. It seems to be the formation most typical of the high plains and extends eastward far into western Kansas and Nebraska.

The season of growth may be divided into two periods: the vernal, or in this case the spring and early summer period; and the aestival, or late summer and autumn period. Each of these grand periods may be divided into two periods: the first into the prevernal and vernal, the second into the aestival and autumnal.

PREVERNAL ASPECT.

Habitat.—Physical and available water content very low. Rainfall 0.48–2.43^{cm} (April 1904, 4.68^{cm}); av. daily, 0.008^{cm}. Relative humidity: mean, 44 per cent.; range 1–100 per cent. Wind 6.09^{hm} per hour. Temperature: mean 7°.2 C.; mean max. 14°.4 C.; mean min. 0° C.; range −11°.1 to 25° C.; soil, 13° C. Light duration 66 per cent., exposure varied, cover open, soil clay to gravel. Duration April.

PRINCIPAL SPECIES: Leucrocrinum montanum Nutt., Townsendia exscapa (Richards) Porter, Pulsatilla hirsutissima (Pursh) Britton.

SECONDARY SPECIES: Cymopterus acaulis (Pursh) Rydb., Phellopterus montanus Nutt.

The winter conditions are xerophytic, there being very little rain and seldom a snow cover. The mean relative humidity is low—40 to 50 per cent., and sometimes falling as low as 1 per cent. The temperature in winter rarely falls below −18° C. and often rises above 16° C. The records show 56 per cent. of possible sunshine,

and the surface of the soil rises to a temperature much higher than that of the air.

To understand and explain the appearance of the vernal and prevernal flora it is necessary to take into account the winter condition. The water content is low at the time of the appearance of the first flowers. The north slopes have a higher percentage of water than the other exposures, and although the temperature is lower it is here that the greatest number of spring flowers are produced. Only very resistant species seem to be able to survive the long dry winter and produce flowers in the spring on the south slopes. The high temperature which the soil of this exposure reaches during the winter would surely start growth at a period when such development would be disastrous to the life of the plant. This probably explains the abundance of the north slope vernal flora and the paucity of the south slope flora during the same period.

Before the spring rains have begun, at the end of the long dry period, this prevernal flora makes its appearance. These plants are never very abundant on the Mesa proper, but appear in great numbers on the hillsides. In each case the flowers appear either without any foliage or with very little.

The most prominent society of this period is the Pulsatilla society, characterized by P. *hirsutissima*. Its distribution within the region studied is limited to the north slopes and it is never found on the south slopes. The plants are often very numerous and constitute almost the only growing vegetation of this period; forming a zone along the north and east slopes of the Mesa which is only interrupted at places of south or southern exposure.

Leucocrinum montanum forms a society which is less exclusive than the former and is at the same time less distinct. It reaches its maximum development on north crests, but may occur in almost any situation except the south exposure. Over the greater part of the Mesa *L. montanum* is mingled with *Townsendia exscapa*, and these two plants constitute the only vegetation of the Mesa top at this period.

Cymopterus acaulis and *Phellopterus montanus* seldom form communities. In their distribution they show a marked alternation,

C. acaulis occurring on the slopes and crests, usually in the gravelly loam, while *P. montanus* is limited to the clay of the lowland.

The flowers of these species are produced early and are short-lived, most of the foliage being produced after the flowers and continuing during the rainy vernal period, after which the surface parts disappear and the living parts lie buried until the following spring.

VERNAL ASPECT.

Habitat.—Physical water: in clay 13–17 per cent.; in gravelly loam 4.5–9 per cent. Non-available water: in clay 8.5–10 per cent.; in gravel 1.5–2.5 per cent. Available water: in clay 5.6–9.3^{gm} to 100^{gm} of dry soil; in gravel 3.2–7.2^{gm}. Rainfall 12.7–27.9^{cm}; av. daily 0.3^{cm}. Relative humidity: mean 54 per cent.; range 11–100 per cent. Wind 5.33^{hm} per hour. Temperature: mean 14°.4 C.; mean max. 20°.5 C.; mean min. 6°.4 C.; range −2.2 −34°.4 C.; soil 12–25° C.; soil surface to 49° C. Light duration 67 per cent. Exposure varied, cover open, soil clay to gravel. Duration May 1 to July 15.

PRINCIPAL SPECIES: Senecio oblanceolatus Rydb., (Thelesperma intermedium Rydb.), Yucca glauca Nutt., Kellermannia yuccogena Ell. & Ev., Pleospora phragmospora Dur. & Mont., Astragalus Drummondii Dougl., Pentstemon angustifolius Pursh, P. secundiflorus Benth., (Opuntia polyacantha Haw.), (Carex stenophylla Wahl.), (Puccinia caracena DC.), Astragalus bisulcatus (Hook.) Gray, Euphorbia robusta (Engelm.) Small, Uromyces scutellatus (Schrank) Lév., Echinocereus viridiflorus Engelm., Arenaria Fendleri Gray, Sophora sericea Nutt., Uromyces hyalinus Pk., (Oreocarya suffruticosa [Torr.] Greene), (Ipomoea leptophylla Torr.).

SECONDARY SPECIES: Lesquerella montana (Gray) Wats., Tetraneuris glabriuscula Rydb., Aragallus Lambertii (Pursh) Greene, (Astragalus mollissimus Torr.), Astragalus crassicarpus Nutt., Lappula occidentalis (Wats.) Greene, Allium reticulatum Don, Oreocarya thyrsiflora Greene, Euphorbia glyptosperma Engelm., Hymenopappus cinereus Rydb., Thalesia fasciculata (Nutt.) Britton, Mertensia linearis Greene, Pentstemon Jamesii Benth., Eriogonum alatum Torr., Cactus viviparus Nutt., Malvastrum coccineum (Pursh) Gray, Cheiranthus arkansanus (Nutt.) Greene, Anogra coronopifolia (T. & G.) Britton, Gaura coccinea Pursh, Euphorbia serpyllifolia Pers., Tradescantia scopulorum Rose, Thelesperma gracile (Torr.) Gray, Astragalus Shortianus Nutt., Nothocalais cuspidata (Pursh) Greene, Erigeron pumilus Nutt., E. flagellaris Gray, E. glandulosus Porter, E. canus Gray, Carex filifolia Nutt., C. pennsylvanica Lam., Vicia americana Muhl., Aecidium porosum Pk., Quincula

lobata (Torr.) Raf., Leucolene ericoides (Torr.) Greene, Meriolix serrulata (Nutt.) Walp., Lithospermum linearifolium Goldie, Anogra albicaulis (Pursh) Britton, Poa longipeduncula Scribn., Salvia lanceolata Willd., Gaura parviflora Dougl., Hedeoma nana (Torr.) Greene, Antennaria imbricata A. Nels., Evolvulus pilosus Nutt., Thelesperma intermedium Rydb., Sitanion elymoides (Torr.) Greene, Oreocarya suffruticosa (Torr.) Greene.

The vernal period, with which the prevernal is sometimes more or less blended, is ushered in by the spring rains and usually extends from about the first of May to the middle of July. The water content is higher at this period than any other, as is also the relative humidity. Extreme temperatures are not recorded, and the conditions for growth are more favorable than at any other time during the year.

This aspect is marked by the appearance of a great number of seedlings and by many showy flowering plants. The floral display is almost entirely of perennial plants. The earliest species generally appear on the north slopes or north crests, a position protected from the high temperature and excessive loss of water during the winter period.

Societies.

Senecio oblanceolatus society.—This society is by far the most important of the vernal period. It reaches its maximum development in the large gullies on the south side of the Mesa, but the species is distributed over practically the whole area.

Yucca glauca society (*fig. 7*).—This species is one of the most conspicuous plants of the Mesa region and in many places becomes dominant for this aspect. Since the plant is perennial, it is at all times one of the most characteristic of this part of the formation. Species of secondary importance in this society are *Senecio oblanceolatus*, *Euphorbia robusta*, *Lesquerella montana*, *Echinocereus viridiflorus*, and *Meriensia linearis*. This society is found on the gravelly soil, often on crests and slopes where the water content is especially low.

Pentstemon angustifolius society.—On crests in the south part of the Mesa this society reaches its best development. Here the species dominates areas of many square meters, almost to the exclusion of any other species. The chief secondary species of this society are *Lesquerella montana* and *Echinocereus viridiflorus*.

Euphorbia robusta society.—This society occurs on most of the hilltops and over rather large areas of the north Mesa. *E. robusta* is less dominant than the controlling species of the societies already mentioned. *Echinocereus viridiflorus* is in point of numbers more abundant but it is comparatively a very inconspicuous plant. *Senecio oblanceolatus* is not dominant in this society, but ranks second in importance to *Euphorbia robusta;* the society very naturally

FIG. 7.—Typical Mesa: Bouteloua formation; *Yucca glauca* society.

grading into the *Senecio oblanceolatus* society almost imperceptibly. Secondary species are *Lesquerella montana, Yucca glauca, Oreocarya thyrsiflora, Aragallus Lambertii, Mertensia linearis,* and *Erigeron pumilus.* The soil is a coarse, gravelly loam; water content 6–9 per cent.

Arenaria Fendleri society.—On crests in coarse gravel or gravelly loam, where the water content is low, this society is found. *A. Fendleri* is dominant, but many other species help to make up

the society. Among the more prominent secondary species are *Tetraneuris glabriuscula*, *Oreocarya thyrsiflora*, *Hymenopappus cinereus*, *Meriolix serrulata*, *Pentstemon angustifolius*, *Tradescantia scopulorum*, and *Lithospermum linearis*.

Pentstemon secundiflorus society.—No species of this aspect is more dominant than is *P. secundiflorus*. On the crests of the east and north sides of the Mesa it forms an extensive society. *Lesquerella montana*, *Echinocereus viridiflorus*, and *Evolvulus pilosus* are secondary species.

Astragalus bisulcatus society.—In the clay on the south, east, and west sides of the Mesa, large clumps of this species are very conspicuous at this time of the year. Its maximum development is at the bottom or near the bottom of the hillsides. It usually occurs alone, but we may also find it associated with *Sophora sericea*, *Quincula lobata*, *Lappula occidentalis*, *Allium reticulatum*, *Malvastrum coccineum*, and *Euphorbia glyptosperma*.

Astragalus Drummondii society.—This is an especially prominent society on north and west slopes, occupying about the same relative position as the *A. bisulcatus* society, but more extensive.

Sophora sericea society.—Although badly affected with *Uroymces hyalinus*, this species becomes the dominant plant in the clay draws of the south Mesa. The chief secondary species associated with it are *Lappula occidentalis*, *Allium reticulatum*, *Malvastrum coccineum*, and *Quincula lobata*.

Communities.

Among the secondary species are found a number which form communities. These are generally of limited extent, but are of species which are widely scattered throughout the formation. The following are the more important communities: *Tetraneuris glabriuscula*, on crests; *Lappula occidentalis*, in semiruderal situations; *Erigeron flageolaris*, at the base of north and west slopes, or on the north and west sides of clumps of oak which have entered from the foothill thicket formation; *E. glandulosus*, on north crests; *Carex filifolia*, on portions of the north Mesa and west slopes; *Quincula lobata*, in clay; *Opuntia polyacantha*, either in clay, or on the gravel crests; *Leucolene ericoides*, on south crests and slopes and other

xerophytic situations; *Pentstemon Jamesii*, on clay knolls in the gullies of the south Mesa; *Malvastrum coccineum*, in semiruderal situations; *Gaura coccinea* and *Thelesperma gracile*, on open coarse gravel of north Mesa; *Poa longipeduncula*, on north slopes; *Salvia lanceolata*, in semiruderal situations; and *Antennaria imbricata*, on northwest and rarely northeast slopes.

Most of these communities are closed and contain very few if any other species belonging to this aspect. Any of the species which form societies will also be found to form communities; in fact some of the societies are merely associations of communities.

General.

The chief societies of the Mesa top are the *Yucca glauca* (*fig. 6*) and the *Senecio oblanceolatus* societies. These become more or less mixed in places on the north Mesa. In many places there is formed a mixed society which varies greatly and can only be regarded as a society made up by mixing the other societies and by the addition of widely distributed secondary species. The Mesa top contains besides the two prominent societies mentioned above, a society marked by *Euphorbia robusta*. These three societies alternate, the last named occurring on the north part, the more open part of the formation, in gravelly loam, where the water content is from 6–10 per cent. The *Yucca glauca* society occupies a somewhat more humid region—the crests and Mesa top, especially where the soil is a rocky, gravelly loam, with water content from 7–12 per cent. The *Senecio oblanceolatus* society reaches its maximum development in the gullies, where the loam has a water content of 10–15 per cent.

In addition to these well-marked societies, the following plants occur in varying numbers over practically the whole Mesa top: *Lesquerella montana*, *Pentstemon angustifolius*, *Aragallus Lambertii*, *Astragalus crassicarpus*, *Oreocarya thyrsiflora*, *Erigeron pumilus*, *E. canus*, *Astragalus Shortianus*, and *Mertensia linearis*. Any or all of these species may occur in the societies noted above.

The gravel crests with a water content of from 4.5–9 per cent. are the most xerophytic situations in the formation; and here are found several societies that alternate. Most of the crests of the north and east sides of the Mesa are occupied by the *Pentstemon*

secundiflorus society; the crests of the south Mesa by the *P. angustifolius* society; and the west crests in either situation or on the west side by the *Arenaria Fendleri* society. The alternation between the first two societies is very marked and may be explained partly by the facts of development. *P. secundiflorus* occurs on soil that is less disintegrated, on coarse gravel, or coarse gravelly loam. *P. angustifolius* occurs in older gravelly loam, where the water content is from 2–4 per cent higher; it seems to be more at home on the plains, while *P. secundiflorus* thrives best in the foothill region. These societies also alternate with the *Arenaria Fendleri* society.

There are in this aspect no well-developed societies on the hillsides. The flora of the slopes however, is rather rich and varied. Practically all of the societies are represented here and one may also find many of the secondary species. Crest forms are especially abundant on the south and east slopes.

The alternation between the *Astragalus bisulcatus* society and the *A. Drummondii* society is partly due to the difference in soil. *A. bisulcatus* occurs in clay and is best developed on south and west exposures, usually at the base of the hills. North and west exposures are the most suitable for *A. Drummondii*, which likewise occurs at the base of the hills.

On the lower land surrounding the Mesa the flora is largely of the *Astragalus bisulcatus* society and of the *Sophora sericea* society, together with the following communities: *Lappula occidentalis*, *Quincula lobata*, *Opuntia polyacantha*, *Malvastrum coccineum*, and *Salvia lanceolata*. This vegetation is in the Ft. Pierre clay, a heavy soil with a water content of 13–17 per cent., 8–10 per cent. of which is not available.

As seen by this arrangement, there is zonation exhibited by these societies. This, however, is not very well marked, and the alternation within the zones is much more distinct than the zones themselves.

The reason for this alternation within the formation is to be found in the physical nature of the soil. The soil of the Mesa is a gravel, mixed with a limited amount of humus and silt, or even clay, and is derived entirely from partly decomposed granite and plant remains. The soil is pervious and there is consequently very little run-off,

except during very heavy rains. The total water content varies with the soil composition from 5–14 per cent., and all but 2–4 per cent. is available to the plant. The crests are of a much looser soil, almost pure gravel in places, but generally mixed with clay and silt. The water content here is from 3–4 per cent. lower than on the Mesa top and the formation is much more open. The clay is closely packed and a large percentage of water which falls runs off. The water content is usually less than 17 per cent. and is often as low as 13 per cent., while the non-available water seems to vary with the plant and the slight differences in the amount of foreign substances in the clay from 8.5–10 per cent. After a rain the soil is easily baked to form a hard crust, and when the soil becomes dry, especially during winter, it cracks open to a considerable depth.

The preference which certain plants show for north and west slopes is easily explained by a glance at the sunshine record for June and July. The morning sun heats the east slopes, and as it rises higher the south slope is strongly heated. This hastens transpiration and water loss. The afternoon is cloudy and very likely rainy. The west slope is consequently not strongly illuminated, the soil temperature is from 2–5° C. lower than on the east and south slopes, and the water content is from 1.5–5 per cent. higher. It is the least xerophytic of any situation in the formation.

AESTIVAL ASPECT.

Habitat.—Physical water: in clay 10–13 per cent.; in gravel 2.5–4.5 per cent. Non-available water: in clay 8.5–10 per cent.; in gravel 1.5–2.5 per cent. Available water: in clay 2.3–3.8^{gm} to 100^{gm} of dry soil; in gravel 1–2.1^{gm} to 100^{gm}. Rainfall 7.59–10^{cm}; av. daily 0.137^{cm}. Relative humidity: mean 51 per cent.; range 9–100 per cent. Wind 4.354^{hm} per hour. Temperature: mean 18.8° C.; mean max. 25° C.; mean min. 10.5° C.; range 2.7°–36.6° C.; soil 18–29° C.; soil surface to 55° C. Light duration 55 per cent. Exposure varied, cover open, soil clay to gravel. Duration July 15 to September 15.

FACIES: Bouteloua oligostachya (Nutt.) Torr., B. hirsuta Lag., (Andropogon scoparius Mich.), (A. furcatus Muhl.), (Calamovilfa longifolia [Hook.] Hack.),

Muhlenbergia gracillima Torr., Agropyrum occidentale Scrib., (Koeleria cristata [L.] Pers.).

PRINCIPAL SPECIES: Artemisia frigida Willd., (Thelesperma intermedium Rydb.), (Schedonnardus paniculatus [Nutt.] Trel.), Gutierrezia Sarothrae (Pursh) Britt. & Rusby, (Grindelia squarrosa [Pursh] Dunal), Chrysopsis villosa (Pursh) Nutt., (Eriogonum annuum Nutt.), (Artemisia canadensis Michx.), Lupinus argenteus Pursh), (Carduus plattensis Rydb.), Aristida longiseta Steud., Psoralea tenuiflora Pursh., Aecidium psoralea Pk., Boebera papposa (Vent.) Rydb., Plantago Purshii R. & S., (Selaginella densa Rydb.), (Eriogonum effusum Nutt.), (Sporobolus cryptandrus [Torr.] Gray), (Eriogonum annuum Nutt.)

SECONDARY SPECIES: Oreocarya thyrsiflora Greene, Petalostemon oligophyllus (Torr.) Rydb., P. purpureus (Vent.) Rydb., Euphorbia glyptosperma Engelm., Thelesperma gracile (Torr.) Gray, Gaura coccinea Pursh, Tetraneuris glabriuscula Rydb., Malvastrum coccineum (Pursh) Gray, Atheropogon curtipendulus (Michx.) Fourn., Sideranthus spinulosus (Nutt.) Sweet, Laciniaria punctata (Hook.) Kuntze, Eriogonum Jamesii Benth., Munroa squarrosa (Nutt.) Torr., Euphorbia serpyllifolia Pers., Chenopodium leptophyllum (Moq.) Nutt., Mentzelia nuda (Pursh) Torr. & Gray, Argemone intermedia Sweet, Physalis comata Rydb., Atriplex argentea Nutt., Potentilla pennsylvanica L., Asclepias pumila (Gray)Vail, Bouteloua prostrata Lag., Helianthus pumilus Nutt., Sitanion elymoides Raf., Muhlenbergia gracilis Trin., Artemisia gnaphalodes Nutt., Stipa comata Trin. & Rupr., Stipa Vaseyi Scrib., Allionia linearis Pursh, Artemisia canadensis Michx., Leucolene ericoides (Torr.) Greene, Picradeniopsis oppositifolia (Nutt.) Rydb., Hedeoma nana (Torr.) Greene, Stipa neo-mexicana (Thurb.) Scrib., Chenopodium oblongifolium Wats., Anogra coronopifolia (T. & G.) Britton, Leptilon canadense (L.) Britton, Helianthus annuus L., Andropogon furcatus Muhl., Solanum rostratum Dunal, Ptiloria ramosa Rydb., Chenopodium album L., Helianthus petiolaris Nutt., Quincula lobata (Torr.) Raf., Grindelia squarrosa nuda (Wood) Gray, Carduus undulatus Nutt., Carduus plattensis Rydb., Gaura parviflora Dougl., Potentilla coloradensis Rydb., Eriogonum alatum Torr., Euphorbia stictospora Engelm., Mentzelia decapetala (Pursh) Urban & Gilg, Andropogon scoparius Michx.

An increase in temperature, a decrease in rainfall and relative humidity, together with the resulting decrease in water content of the soil mark the appearance of the aestival period. The percentage of water in the soil is for this period 10–13 per cent. for clay and 2.5–4.5 per cent. for gravel.

This aspect is characterized by the flowering of most of the annual species and by the predominance of the grasses and composites. The facies of the formation are the dominant species of this aspect

and in consequence the principal species are less conspicuous than during the vernal period.

Consocies.

Consocies or areas dominated by the facies of the formation will be discussed later, and need only be mentioned here.

Bouteloua oligostachya consocies.—This consocies is almost as extensive as is the formation, for this species is by far the most abundant of any found in the region studied. A discussion of the consocies is practically a discussion of the typical grama grass formation and will be taken up later. The highest development of this consocies is on the Mesa top, where the water content of this period in the gravelly loam is 4–8 per cent.

Bouteloua hirsuta consocies.—This consocies occupies a more xerophytic habitat, where the water content is 2.5–4.5 per cent. It occurs on the crests and on the north portion of the Mesa in the gravelly soil. With this plant are generally associated *Artemisia frigida*, *Atheropogon curtipendulus*, *Aristida longiseta*, *Bouteloua oligostachya*, *Gutierrezia Sarothrae*, and many crest species. Conditions here are the most xerophytic of any situation in the habitat.

Muhlenbergia gracillima consocies.—This consocies is characteristic of the clay flats where it reaches its best development. It is not uncommon to find places which are dominated by this species almost to the exclusion of everything else. As a rule, however, one finds here *Bouteloua oligostachya*, *Schedonnardus paniculatus*, *Artemisia frigida*, *Gutierrezia Sarothrae*, *Munroa squarrosa*, *Boebera papposa*, *Plantago Purshii*, *Picradeniopsis oppositifolia*, *Euphorbia glyptosperma*, *Argemone intermedia*, *Atriplex argentea*, *Agropyron occidentale*, *Malvastrum coccineum*, and many other secondary species. The habitat is xerophytic, in clay or loam where the water content varies with the soil composition from 17–13 per cent.; the available water being from 2–3.5^{gm} per 100^{gm} of dry soil.

Agropyron occidentale consocies.—This is not so important in the Mesa region as it is farther east. It occurs, however, in the clay, and here is usually associated with *Muhlenbergia gracillima*, *Bouteloua oligostachya*, *B. prostrata*, and *Atriplex argentea*.

Societies.

Artemisia frigida society.—This is by far the most important society of the region. It occurs at the heads of the gullies and on the more depressed places of the north Mesa. It is also important on alluvial fans and areas where there has been a secondary succession. Where this species is abundant, as a rule it shuts out all other plants with the exception of the taller species, such as *Argemone intermedia* and *Stipa Vaseyi*. This society can be distinguished for miles because of the silvery appearance of the plant, which is so widely distributed over the entire Mesa that it would be considered a facies of the formation if it were not for the fact that more extended study shows it to be local in its distribution.

Gutierrezia Sarothrae society.—This composite is rather evenly distributed over the Mesa region, but it can never be said to replace the grasses which are characteristic of the formation. It does dominate rather large areas, however, particularly in the southern part of the Mesa, where it is found associated with many of the characteristic plants of the Mesa top. It does not occur so commonly in the purer gravel soil as in the clay and gravelly loam.

Chrysopsis villosa society.—This society is of considerable importance on the north portion of the Mesa, where it occurs in the *Bouteloua hirsuta* consocies.

The *Aristida longiseta* society is not extensive, but dominates south and east crests and slopes. The *Psoralea tenuiflora* society is extensive, reaching its best development on the hillsides.

The rainy vernal period favors the development of a number of annuals which come into bloom at this time. The most important of these is *Boebera papposa*, which has a very even distribution throughout the region studied. It occurs as a ruderal plant, usually from 4–10^{cm} high and bearing very often only one head. In point of numbers it probably exceeds all but the facies of the formation. However, it succeeds best as a ruderal, and in the formation the small plants may be as numerous as 996 per quadrat and still not be especially noticeable. Wherever there are open spaces in the formation, this society is found.

Plantago Purshii also occurs as an important annual in the forma-

tion. It is also successful as a ruderal, but at places within the formation may become far more numerous than any other species.

Communities.

The following communities also occur: *Schedonnardus paniculatus*, near the mountain and in clay; *Atheropogon curtipendulus*, on north slopes; *Sideranthus spinulosus*, on south slopes and crests; *Atriplex argentea*, in ruderal clay; *Bouteloua prostrata*, in clay south of the Mesa, also in ruderal or semiruderal habitats; *Sitanion elymoides*, on south slopes; *Muhlenbergia gracilis*, on north slopes; *Artemisia canadensis*, on north and west slopes; *Leucolene ericoides*, crests and xerophytic places; *Andropogon furcatus*, on north Mesa in gravel; *Andropogon scoparius*, on gravel crests; *Thelesperma gracile* and *Gaura coccinea* continue from the previous aspect.

Within this area there is one family of *Oonopsis foliosa* (Gray) Greene, which is about three years old and has spread to occupy 25^{sqm}.

General.

In considering the aestival aspect as a whole, much is found that will be discussed under the formation. Zonation during this aspect is shown as in the preceding aspect. The Mesa top is dominated by the typical formation—*Bouteloua oligostachya* consocies—the crests by the *B. hirsuta* consocies, the hillsides by the typical formation tending towards the *B. hirsuta* consocies, and the low lands surrounding either by the typical formation or by this alternating with the *Muhlenbergia gracillima* or *Andropogon occidentale* consocies.

This zonation is largely due to differences in water content. The Mesa top and the slopes have nearly the same water content, there being about $2–3^{gm}$ of available water; the crests have a less amount, $1–2^{gm}$; while at the base, in the clay, the available water is from $2.3–3.8^{gm}$.

The greater part of the Mesa top is occupied by the *Bouteloua oligostachya* consocies. Almost any of the other species noted under this aspect, whether they are primary or secondary, may be found associated with *B. oligostachya*. The most noticeable forms found on the Mesa at this time are *B. oligostachya*, *Muhlenbergia*

gracillima, *Bouteloua hirsuta*, *Artemisia frigida*, *Gutierrezia Sarothrae*, *Boebera papposa*, *Oreocarya thyrsiflora*, *Chrysopsis villosa*, *Schedonnardus paniculatus*, *Petalostemon oligophyllus*, *P. purpureus*, *Psoralea tenuiflora*, *Thelesperma gracile*, *Gaura coccinea*, *Euphorbia glyptosperma*, *Atheropogon curtipendulus*, *Sideranthus spinulosus*, *Lacinaria punctata*, *Eriogonum Jamesii*, *E. effusum*, *Asclepias pumila*, *Helianthus pumilus*, *Sitanion elymoides*, *Artemisia gnaphalodes*, *Castilleia integra*, *Erigonum alatum*, *Pentstemon unilateralis*, *Stipa Vaseyi*, and *Euphorbia stictospora*.

Besides the typical formation, the north Mesa is occupied by the *Bouteloua hirsuta* consocies. In this consocies the following groups occur: the *Chrysopsis villosa* society occupying rather limited areas, low crests, and south slopes; and the following communities: *Sideranthus spinulosus*, *Artemisia gnaphalodes*, *Andropogon furcatus*, and *A. scoparius*.

The crests are the most xerophytic and are occupied by the *Bouteloua hirsuta* consocies. This may alternate, however, with the *B. oligostachya* consocies. Occurring within the former consocies are often found the *Gutierrezia Sarothae*, *Chrysopsis villosa*, and the *Aristida longiseta* societies, as well as the following communities: *Sitanion elymoides*, *Muhlenbergia gracilis*, *Artemisia gnaphalodes*, *Andropogon scoparius*, and *Tetraneuris glabriuscula*. The following plants are also abundant on these crests: *Oreocarya thyrsiflora*, *Chenopodium leptophyllum*, *Stipa comata*, and *S. neo-mexicana*.

The hillsides and slopes have usually about the same vegetation as the Mesa top, but the crest forms may be more abundant.

Passing to the lowlands, the *Bouteloua oligostachya* consocies is found alternating with the *Muhlenbergia gracillima* consocies and also the *Andropogon occidentale* consocies. The chief societies of the *Bouteloua oligostachya* consocies are the *Gutierrezia Sarothrae* and *Artemisia frigida* societies. In the Muhlenbergia consocies are found the *Bouteloua prostrata* and *Atriplex argentea* communities.

Marked alternations sometimes occur between secondary species. *Petalostemon oligophyllus* occurs on south and east slopes, and *P. purpureus* on north and west slopes, where the water content is from 1–2 per cent. higher; *Muhlenbergia gracile*, *Koeleria cristata*, and *Potentilla pennsylvanica* are usually found on north slopes;

while *Aristida longiseta*, *Sitanion elymoides*, *Stipa comata*, *S. neomexicana*, *Physalis comata*, and *Ptilora ramosa* are found on south slopes and crests.

AUTUMNAL ASPECT.

Habitat.—Physical water: in clay 8.5–10 per cent.; in gravel 1.5–2.5 per cent. Non-available water: in clay 8.5–10 per cent.; in gravel 1.5–2.5 per cent. Available water: none in surface soil. Rainfall 1.62–4.03^{cm}; av. daily .006^{cm}. Relative humidity: mean 49 per cent.; range 12–100 per cent. Wind 4.66^{hm} per hour. Temperature: mean 11.6°C.; mean max. 18.8°C.; mean min. 2.7°C.; range −5.5°−27.2°C.; soil 18–25°C.; soil surface to 40°C. Light duration 60 per cent. Exposure varied, cover open, soil clay to gravel. Duration September 15 to November 1.

PRINCIPAL SPECIES: Artemisia frigida Willd., Gutierrezia Sarothrae (Pursh) Britt. & Rusby, (Grindelia squarrosa [Pursh] Dunal), Senecio spartioides Torr. & Gray, *Chrysopsis villosa (Pursh) Nutt., Chrysothamnus graveolens (Nutt.) Greene.

SECONDARY SPECIES: Lacinaria punctata (Hook.) Kuntze, Oreocarya thyrsifloria Greene, Eriogonum Jamesii Benth., Aster polycephalus Rydb., Machaeranthera cichoriacea Greene, Tetraneuris glabriuscula Rydb., Munroa squarrosa (Nutt.) Torr., Petalostemon purpureus (Vent.) Rydb., P. oligophyllus (Torr.) Rydb., Artemisia canadensis Michx., A. gnaphalodes Nutt., Grindelia squarrosa (Pursh) Dunal, Leptilon canadense (L.) Britton, Machaeranthera viscosa Nutt., Chrysothamnus plattensis Greene, Grindelia squarrosa nuda (Wood) Gray, Eurotia lanata (Pursh) Moq.

During the month of August the rainfall decreases markedly, and is only slight during September. The temperature at this time is as high as at any time during the year, and the result is the rapid loss of water by the soil. Although there is still 8–10 per cent. of water in clay and 1.5–2.5 per cent. in gravel, it is doubtful if there is any available water in the surface soil.

Although many plants continue to bloom, vegetative growth is practically stopped for all annuals and greatly decreased for perennials. There must still be some available water, but all the annual plants which would ordinarily continue to grow and bloom if supplied with only a limited amount of water, have dried up at the

beginning of this period. The grasses are dried, and although they are still a prominent part of the vegetation, they are not a living part. It is an exceedingly xerophytic time, and the plants which are found in this aspect appear throughout the vernal and aestival periods and are now only blooming and ripening their seeds.

Artemisia frigida and *Muhlenbergia gracillima* continue to occupy a most important place. *Senecio spartioides* forms in places an extensive society; while the *Gutierrezia Sarothrae* society is even more noticeable than during the aestival period. *Chrysothamnus graveolens*, a large shrubby composite, forms a small society within this region, but farther east occupies larger areas; it is one of the most showy plants of this aspect. *Aster polycephalus* and *Machaeranthera cichoriacea* form rather extensive communities in the more open parts of the formation. *Chrysopsis villosa*, *Lacinaria punctata*, *Oreocarya thyrsiflora*, *Eriogonum Jamesii*, *Tetraneuris glabriuscula*, *Petalostemon oligophyllus*, *P. purpureus*, *Aristida longiseta*, *Grindelia squarrosa*, *G. squarrosa nuda*, *Artemisia canadensis*, and *A. gnaphalodes* have continued from the preceding period.

The end of this period is not well marked. The plants are dry and resistant, and although frost kills the plants which have a more liberal supply of water, some of these species may continue to bloom as late as December 10. During this late period *Senecio oblanceolatus*, *Argemone intermedia*, *Lesquerella montana*, and a number of other species form rosettes which continue throughout the winter.

Structure of the formation as illustrated by typical quadrats.

Passing now from the aspects to the formation as a whole, the structure may be illustrated best by a number of permanent quadrats. Those species which form mats cannot be well represented in numbers per square meter, and on this account the percentage of surface covered is given instead. The numbers which are also given for these species indicate single plants or seedlings. An estimate is also given of the total amount of surface covered by plant growth.

The following quadrat is typical of the *Bouteloua oligostachya* consocies—the most typical portion of the Bouteloua formation.

Bouteloua oligostachya	134	22%	Senecio spartioides	4	
Muhlenbergia gracillima	5	7%	Sideranthus spinulosus	12	
Artemisia frigida	6	5%	Boebera papposa	81	
Senecio oblanceolatus	9		Plantago Purshii	2	
Aristida longiseta	1		Polygonum aviculare	1	
Astragalus Shortianus	1		Townsendia exscapa	1	
Schedonnardus paniculatus	1		Bryum argenteum		
Chrysopsis villosa	1		Total surface covered		42%

Water content: vernal period 8–13%; aestival 6–8%; autumnal 5–6%. Soil, gravelly loam.

The most important difference in the habitat is in water content, the other factors being practically the same as given under the aspects of the formation.

The following quadrats are also typical of the *Bouteloua oligostachya* consocies, but represent this consocies as modified by the occurrence within it of societies.

Bouteloua oligostachya	47%		Euphorbia stictospora	9	
Artemisia frigida	4.5%		Boebera papposa	996	
Anogra coronopifolia	21		Anogra albicaulis	2	
Senecio oblanceolatus	1		Total surface covered		56%

Water content: vernal period 6–12%; aestival 46%; autumnal 3–4%. Soil, fine gravelly loam.

A quadrat within a *Gutierrezia Sarothrae* society:

Bouteloua oligostachya	168		Eriogonum effusum	5	
Gutierrezia Sarothrae	22		Boebera papposa	5	
Artemisia frigida	10		Malvastrum coccineum	6	
Sideranthus spinulosus	18				

Water content: vernal period 7–15%; aestival 4–7%; autumnal 2–4%. Soil, coarse gravelly loam mixed with lime.

The following quadrat will serve to illustrate a portion intermediate between the *Bouteloua oligostachya* consocies and the *Muhlenbergia gracillima* consocies.

Muhlenbergia gracillima	20	33%	Boebera papposa	36	
Bouteloua oligostachya	24	12%	Atheropogon curtipendulus	1	
Sideranthus spinulosus	3		Allionia linearis	1	
Malvastrum coccineum	5		Echinocereus viridiflorus	1	
Artemisia frigida	2		Total surface covered		47%

Water content: vernal period 8–14%; aestival 6–8%; autumnal 5–6%. Soil, loam.

Muhlenbergia gracillima consocies.—This consocies covers the greater part of the lower land, particularly that south of the Mesa. The following quadrat is typical.

Muhlenbergia gracillima	46%		Boebera papposa		25
Schedonnardus paniculatus	6%		Plantago Purshii		9
Bouteloua oligostachya	1%		Senecio oblanceolatus		1
Artemisia frigida	19	1.5%	Hedeoma nana		1
Munroa squarrosa	1		Salvia lanceolata		1
Gutierrezia Sarothrae	9		Euphorbia glyptosperma		1
Picradeniopsis oppositifolia	3		Total surface covered		56%

Water content: vernal period 9–14%; aestival 7–9%; autumnal 5–7%. Soil, loam.

This consocies should also show *Opuntia polyacantha, Stipa Vaseyi, Argemone intermedia, Senecio spartioides, Verbena bracteosa, Atriplex argentea, Malvastrum coccineum, Astragalus crassicarpus, A. bisulcatus, Sophora sericea, Quinculata lobata, Agropyron occidentale,* and many others.

In places *Muhlenbergia gracillima* is even more dominant than in the quadrat given above, but as one passes to the higher ground it gives way gradually to *Bouteloua oligostachya.*

Bouteloua hirsuta consocies.—This consocies is best developed on the crests and over the north portion of the Mesa. A quadrat best illustrates the structure.

Bouteloua hirsuta	95	17%	Sideranthus spinulosus		7
Artemisia frigida		4%	Oreocarya thyrsiflora		6
Atheropogon curtipendulus		1.5%	Lacinaria punctata		4
Aristida longiseta	4	1%	Gaura coccinea		3
Andropogon scoparius		.5%	Euphorbia robusta		2
Bouteloua oligostachya		.3%	Senecio spartioides		1
Thelesperma gracile	16		Astragalus Shortianus		1
Echinocereus viridiflorus	8		Pentstemon secundiflorus		1
Senecio oblanceolatus	7		Total surface covered		32%

Water content: vernal period 4.5–9%; aestival 2.5–4.5%; autumnal 1.5–2.5%. Soil, coarse gravelly loam. This quadrat also illustrates the structure of the vernal *Euphorbia robusta* society.

While *Bouteloua hirsuta* is predominant in this consocies, many other species are important. *Muhlenbergia gracillima* is sometimes present; *Aristida longiseta* and *Sitanion elymoides* are sometimes

very important; *Andropogon furcatus*, *Yucca glauca*, *Erigeron pumilus*, and *E. canus* are often present.

The physical conditions of this consocies are not essentially different from those of the typical formation, except that the looser, gravelly soil contains less water. It is the most xerophytic of all the consocies. The following crest quadrat from the south part of the Mesa also illustrates this consocies.

Bouteloua hirsuta	35	10%	Artemisia frigida	2	
Bouteloua oligostachya	34	3%	Senecio oblanceolatus	2	
Aristida longiseta	8	1.5%	Gaura coccinea	1	
Atheropogon curtipendulus	30	.5%	Oreocarya thyrsiflora	1	
Gutierrezia Sarothrae	7		Echinocereus viridiflorus	1	
Senecio spartioides	3		Lecanora subfusca allophana*	20	
Pentstemon angustifolius	3		Total surface covered		23%

* Small crusts—a remnant of the more primitive lichen formation.

Water content: vernal period 6–10%; aestival 4–6%; autumnal 2.5–4%. Soil, very coarse gravelly loam.

Societies of the *Bouteloua hirsuta* consocies: *Pentstemon secundiflorus* society found on crests of the north or east part of the Mesa. The following quadrat is typical:

Pentstemon secundiflorus, (81 in bloom)	141		Evolvulus pilosa	7	
Artemisia frigida		7%	Sideranthus spinulosus	6	
Bouteloua hirsuta	65		Echinocereus viridiflorus	2	
Lesquerella montana (seedlings)	40		Mentzelia nuda	4	
Boebera papposa	8		Portulaca oleracea	1	
			Total surface covered		24%

Water content: vernal period 4.5–9%; aestival 2.5–4.5%; autumnal 1.5–2.5%. Soil, coarse gravelly loam.

Pentstemon angustifolius society.—While *Pentstemon angustifolius* does not form so dense an association as *P. secundiflorus*, the spikes are much larger, and it is therefore very prominent in certain areas. The following quadrat is typical:

Bouteloua hirsuta	17	20%	Artemisia canadensis	2	
Pentstemon angustifolius	14	(5%)	Eriogonum Jamesii	1	
Aristida longiseta		1%	Thelesperma gracile	1	
Chrysopsis villosa	8		Boebera papposa	4	
Allionia linearis	5		Euphorbia stictospora	4	
Echinocereus viridiflorus	2		Total surface covered		28%
Gutierrezia Sarothrae	2				

Water content: vernal period, 6–12%; aestival 4–6%; autumnal 2–4%. Soil, coarse gravelly loam.

This society belongs to the vernal aspect and alternates markedly with the above-mentioned society. So distinct is this alternation, that on adjacent crests these societies may occur with no mixing of the dominant species. It occupies the south and west crests of the Mesa. The species is widely distributed over the top of the Mesa, but seldom becomes dominant.

The following quadrat is taken from a community of *Leucolene ericoides:*

Leucolene ericoides	78	Eriogonum Jamesii	1
Bouteloua hirsuta	53	Psoralea tenuiflora	1
Aristida longiseta	13	Allionia linearis	1
Eriogonum effusum	3	Chenopodium leptophyllum	1

The *Agropyron occidentale* consocies is not as well developed in this region as elsewhere, but the following quadrat will show the structure. This quadrat is taken from a community of *Bouteloua prostata.*

Bouteloua prostrata	352	Salvia lanceolata	11
Agropyron occidentale	216	Polygonum aviculare	10
Bouteloua oligostachya	47	Picradeniopsis oppositifolia	9
Boebera papposa	123	Quincula lobata	4
Verbesina encelioides	108	Salsola Tragus	2
Gutierrezia Sarothrae	23		

Water content: vernal period 13–17%; aestival 10–13%; autumnal 8.5–10%. Soil, clay.

General discussion.

While the vegetation of the Mesa is typical of the high plains, it does not show all of the structure that is at once apparent upon the examination of a larger area. On the Great Plains lying east, this formation is everywhere in evidence. By far the most important species is *Bouteloua oligostachya*—the dominant species of the formation. That part of the formation which is most typical is the *B. oligostachya* consocies. This consocies is much more closed and pure on the great level plateau farther east than it is near the mountains. It often covers as much as 60–70 per cent. of the surface, and is associated with very few primary or secondary species. In

the clay flats it often gives way to the *Muhlenbergia gracillima* or *Agropyron occidentale* consocies, and in passing to sandy or gravelly ridges it is often dominated by the *Bouteloua hirsuta, Andropogon scoparius,* or *Koeleria cristata* consocies. Even on the slopes or more level sandy areas it alternates with the *Calamovilfa longifolia* consocies, and at times with the *Andropogon furcatus* consocies. Although these consocies dominate immense areas, they are not to be regarded as constituting distinct formations. *Bouteloua oligostacyha* is prominent everywhere and these are merely modifications of the Bouteloua formation, or in other words, consocies of this formation.

To discuss each aspect of this formation would take too much space, and some idea may be obtained by referring to the lists given earlier in this paper.

There is a rather marked zonation in regions characterized by rolling or uneven ground. The hills and ridges are occupied by *Bouteloua hirsuta.* In this habitat there is a rather marked alternation with other consocies. *Andropogon scoparius* often becomes dominant, as does also *Koeleria cristata.* Here are also found a number of prominent societies, among which the most xerophytic is the *Selaginella densa* society. *Sporobulus cryptandrus* and *Stipa comata* may also become prominent.

Occupying the sides of the slopes and the level expanses is the extensive *Bouteloua oligostachya* consocies. Alternating with this is found the *Andropogon furcatus* and the *Calamovilfa longifolia* consocies. This alternation is often very marked, the consocies remaining distinct from each other.

It is here that the most important societies of the formation are found, many of which extend for many miles without interruption. Among the most prominent of these societies is the *Grindelia squarrosa* society, which extends for many miles east of Limon, Col., and occurs over less extensive areas in many other parts of the formation. The *Schedonnardus paniculatus* society occurs throughout the formation and in many places is very extensive. Between Burlington, Col., and Goodland, Kans., the society extends for many miles. *Thelesperma intermedium* also occurs in this consocies. It is one of the most prominent societies in the formation and is especially

well developed just east of Colorado Springs. The *Gutierrezia Sarothrae* society occurs more often near the mountains and bluffs. *Artemisia canadensis* is also important in similar locations, while *A. dracunculoides* is most abundant farther out on the plains. *Opuntia polyacantha* in most places merely forms small communities or families, but in many places on the plains these become associated into an extensive society. This is especially true east and south of Fountain, Col. *O. arborescens* is also found in this region and extends northward to within a few miles of Colorado Springs.

Carex stenophylla, Senecio oblanceolatus, Sophora sericea, Astragalus Drummondii, Oreocarya suffruticosa, Eriogonum annuum, Chrysopsis villosa, Boebera papposa, and *Plantago Purshii* each form extensive societies in this consocies. The following societies are not so extensive, but on account of the prominence of the plants characterizing them they are very noticeable: *Ipomoea leptophylla, Yucca glauca, Lupinus argenteus, Carduus plattensis, Eriogonum effusum, Chrysothamnus graveolens, Senecio spartioides, Pentstemon angustifolius, P. secundiflorus,* and *Astragalus bisulcatus.*

Passing now to the lowlands, the *Bouteloua oligostachya* consocies is found with very few primary or secondary species, and usually alternating with the *Muhlenbergia gracillima* and the *Agropyron occidentale* consocies. These consocies are sometimes mixed, but as a rule remain distinct. *Agropyron occidentale,* a tall slender grass, is usually not associated with many other species, and the mats of *Muhlenbergia gracillima* also leave little space for the development of any but a few of the clay-loving annuals. *Astragalus bisulcatus, Sophora sericea, Boebera papposa, Plantago Purshii,* and *Atriplex argentea* are among the most important secondary species of these consocies.

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CONTRIBUTIONS FROM THE ROCKY MOUNTAIN HERBARIUM. VII.

AVEN NELSON.

Cypripedium Knightae, n. sp.—Stem short, 3–7^{cm} high, sparsely and coarsely villous, bearing a single pair of nearly opposite leaves at its summit: leaves oval, generally rounded and obtuse, thickish, 4–7^{cm} long: peduncle glandular-viscid, 3–10^{cm} long, usually naked, rarely with a lanceolate bract near the middle: floral bracts rather large, elliptic-lanceolate: flowers 2 or 3 in a cluster, dark-purple: lower sepals united nearly to the tip, ovate-lanceolate, the two together no broader than the other sepal: petals similar, a little broader than the sepals: lip 10–12^{mm} long, somewhat shorter than the sepals and petals, the deeply infolded free margin deep-purple, the lower part of the sac ochroleucous or greenish-yellow: sterile anther elliptic, obtuse, much shorter and smaller than the large conspicuous stigma.

This species, in so far as it has been collected, has seemingly passed as *C. fasciculatum* Kellogg, Wats. Proc. Am. Acad. 17:380. That is a very different thing, as may be seen by referring to the original description, or to Howells's Fl. N. W. Am. 632. It is, moreover, of a quite different geographical range. I have great pleasure in naming this fine species for Miss Harriet Knight, whose sympathetic interest in all nature and whose intelligent activity in the educational work of Wyoming is greatly appreciated.

Collections at hand: *Miss Knight*, Medicine Bow Mts., Wyo., at Cooper Hill, July 1905 (type); *L. N. Goodding*, no. 1201, Uinta Mts., Utah (Dyer Mine), June 30, 1902; *G. E. Osterhout*, Estes Park, Colo., July 1897; and Encampment Creek, Sept. 1897.

Montia Viae, n. sp.—Annual, with fibrous roots: stems and petioles weak, suberect, 10–15^{cm} high: leaves delicately thin, pale-green; the radical several, slender-petioled, the short blades from linear to oval, acute; the single pair of cauline connate and forming a circular or slightly irregular involucral disk 10–20^{mm} broad: raceme peduncled, with a pair of green bracts at the base of the lower pedicels: flowers very small, several: sepals broadly oval, even in fruit less than 2^{mm} long: petals 5, spatulate, barely equalling the sepals,

very delicate, apparently often wholly wanting: stamens 5, very short: ovule solitary; the seed small, oval, slightly compressed and subcarinate, minutely but distinctly papillose-roughened and with a waxy conspicuous strophiole.

Most nearly related but very distinct from *M. perfoliata* (Donn.) Howell, Erythea 1:38, a plant of the Pacific states. Possibly all of the central Rocky Mountain specimens named *M. perfoliata* belong here. The type specimens were collected by the Misses *Dorothy Reed* and *Vie Willits*, June, 1905. Miss Willits, in whose honor the plant is named, later secured an abundance of fruiting specimens. Type locality, shady muddy banks, Big Horn, Sheridan Co., Wyoming.

Lesquerella latifolia, n. sp.—Perennial, silvered with a fine lepidote stellate pubescence throughout: stems numerous, from among the crowded rosulate crown leaves, decumbent at base, spreading, 5–15^{cm} long: radical leaves suborbicular, oval, or rhombic, sometimes broader than long, from 1–3^{cm} in diameter; the petioles slender, often much longer than the blade; cauline leaves from broadly obovate to spatulate, all cuneately tapering into a slender petiole: racemes of showy bright-yellow flowers dense, elongating in fruit: petals spatulate, 9–10^{mm} long, twice as long as the oblong sepals: siliques elliptic, very perceptibly stipitate, 5–6^{mm} long, erect on S-shaped pedicels of about the same length; style slender, 3–4^{mm} long; cells about 5-ovuled.

This is based upon Mr. L. N. Goodding's no. 625, from Karshaw, Meadow Valley Wash, southern Nevada, Apr. 26, 1902. It has been distributed as *L. montana*, a species from which it is as far removed as to characters as it is geographically.

Lesquerella Lunellii, n. sp.—Pale green, moderately and minutely stellate-pubescent throughout: caudex a mere crown surmounting the slender tap root: stems few to several, ascending or assurgent, very slender (almost filiform), 3–15^{cm} long (including the raceme): leaves narrowly linear-oblanceolate, 1–2^{cm} long; the lower tapering into the slender petioles: raceme at length open and long for the plant: sepals purplish-green, linear-oblong, subacute, 4–5^{mm} long: the spatulate-obovate petals nearly twice as long, the upper half of the blade a fine purple, shading into the yellow of the lower half and the claw: silique globose, 4–5^{mm} in diameter; the slender

style as long and the ascending or often recurved pedicel usually distinctly longer.

Dr. *J. Lunell*, of Leeds, N. D., an enthusiastic student of the northwest flora, communicated the specimens to me. I have pleasure in naming the species in his honor. He writes: "It grows on high barren hills among rocks. Its petals are broadly purple-tipped, and the base a bright-yellow." Collected at Butte, Benson Co., N. D., June 13, 1905.

Lepidium Zionis, n. sp.—Glabrous perennial, 1–2^{dm} high: stems several from the crown of a rather thick semi-fleshy vertical root, decumbent at base but assurgent-erect, each corymbosely branched at summit: all the leaves erect, quite entire, thick or subcoriaceous, acute or apiculate; radical leaves oblong, 2–3^{cm} long, tapering to a slender petiole as long as the blade; cauline leaves very numerous, almost imbricated, linear-lanceolate, 15–25^{mm} long: racemes short, crowded: sepals elliptic, scarious margined, half as long as the obovate-cuneate white rather conspicuous petals: stamens 2: silique ovate or elliptic, somewhat keeled, glabrous, not emarginate; the style and small stigma one-fourth as long.

This quite unusual species rests upon but one collection at present, *M. E. Jones'* no. 5411, Richfield, Utah, June 13, 1894.

Cardamine incana (Gray), n. n.—*C. cordifolia incana* Gray, Jones in Proc. Cal. Acad. Sci. II. **5**:620. 1895; *C. cardiophylla* Rydb. Bull. Torr. Bot. Club **28**:280. 1901; not *C. cardiophylla* Greene, Man. Bot. 19. 1894.

Euphorbia Aliceae, n. sp.—Perennial from slender horizontal rootstocks, glabrous or slightly puberulent, 10–15^{cm} high: stem branching from the base, the branches spreading-decumbent: leaves narrowly oblanceolate, short-petioled, sharply serrate, opposite, more crowded toward the terminal clustered involucres: involucres nearly sessile, small, turbinate, somewhat fimbriate-margined; the glands about 4, small, short-stipitate, sometimes minutely cornuate or even obscurely appendaged: capsule glabrous: seeds subcubical, with a caruncle, slightly tuberculate, ashy.

Known as yet only from Hartville, Wyoming, no. 549, collected July 15. 1894. Named in honor of Mrs. *Celia Alice Nelson*, whose industry as a collector is responsible for thousands of specimens found in the leading herbaria, although her name has never appeared on a plant label.

Delphinium Cockerelli, n. sp.—Tawny-pubescent on stems and in the inflorescence, densely and viscidly so above; the leaves obscurely pubescent: stems nearly simple or bushy-branched, 6–12^{dm} high: leaves large, often 12–18^{cm} in diameter, the veins strikingly superficial, about 5-cleft or parted into broadly oblong or oblong-cuneate divisions, these merely coarsely toothed or incised above the middle: racemes often several, open, with rather long peduncles and pedicels and few flowers (5–10): flowers bright-purple, large (3–4^{cm} long): sepals oblong-lanceolate, acute, about as long as the thick curved spur: petals small; the upper yellowish-white, concealed within the upper sepal; the lower purple, with suborbicular blade, cleft and sparsely hirsute ciliate.

An unusually handsome species, with somewhat the aspect of *A. subalpinum* (Gray) A. Nels. Bull. Torr. Bot. Club **27**:263. The type was collected by Mrs. *O. St. John*, no. 90, Baldy Mts., Elizabethtown, N. M., Oct., 1898. It was communicated to me by Professor Cockerell, who called my attention to some of its distinguishing characters. *C. F. Baker's* no. 325, near Pagosa Peak, Colo., is also quite typical.

Aconitum lutescens, n. sp.—Root small, fusiform-tuberous: stems slender, simple, erect, only 3–6^{dm} high, glabrous nearly to the inflorescence: leaves 3–5^{cm} broad; the 5 broadly cuneate divisions deeply and incisely toothed above the middle: raceme narrow, long for the plant, rather open; the flowers a pure cream-color, becoming nearly white or pinkish in drying; rachis and pedicels softly hirsute-ciliate with straight viscid hairs standing out at right angles.

This Aconitum with its fine cream-colored flowers may best stand as a species. Collections of it are as follows: *Aven Nelson*, no. 1521 (type), Cummins, Wyo., July 1895; *T. D. A. Cockerell*, no. 87, Beulah, N. M., 1898; *W. S. Cooper*, no. 274, Estes Park, Colo., July 1904.

Anemone zephyra, n. sp.—Green but sparsely long-pilose: stems one or more from the thick erect caudex, 7–15^{cm} high, rather stout: basal leaves petioled, ternate, the broad petiolulate segments in turn deeply incised into linear-oblong lobes; involucral leaves sessile, with linear-oblong lobes: flowers large, 2–3^{cm} broad, lemon-yellow or ochroleucous, usually solitary and rather long-pedunculate, sometimes umbellately 2–4-flowered: achenes large, glabrous, obovate, tapering to a stipe-like base, tipped with the short hooked style.

There seems to be no good reason for continuing the name *A. narcissiflora* for this plant of the central Rocky Mountains. That Arctic species is white-flowered, the flowers very closely umbelled in the involucre, and the leaves are cleft into many more lobes than ours. The proposed species probably includes all the specimens from the Rocky Mountains of the United States distributed as *A. narcissiflora* or *A. albomerus* (ined.).

Anemone stylosa, n. sp.—Low from a thickened simple or branched caudex densely covered with the dead sheathing petioles: basal leaves pale green, glabrous, biternate, segments 3-parted, again incised into linear-lanceolate acute lobes; involucral leaves short-petioled, otherwise quite similar: stems and petioles sparsely long-pilose, the hairs spreading or refracted: sepals oval or oblong, purplish red or greenish red: achenes pubescent, with rather long straight glabrous persistent styles hooked at the tip.

This I take it is the plant referred to *A. tetonensis* in Syn. Fl. N. A. 1:10. As yet reported only from type locality, Fish Lake, Utah, *M. E. Jones*, nos. 5763 and 5764, Aug. 7, 1894.

Clematis plattensis, n. sp.—Stems clustered on the crown of a thick woody root, 12–18^{cm} high, terminated by the single stout peduncle of nearly equal length in fruit, sparsely short-villous: basal leaves small, scale-like and entire: foliage proper of about 3 pairs of nearly simply pinnate short-petioled leaves; pinnae 7–9, the lowest pair sometimes ternate, all distinctly petiolulate (petiolule 3–10^{mm} long) and long-villous: achenes long-tailed, hairy-plumose: flowers not known, presumably much like those of *C. Douglasii*.

Type from the North Platte Cañon, in eastern Wyoming, *Aven Nelson*, no. 8355, July 2, 1901.

RANUNCULUS JOVIS A. Nels. Bull. Torr. Bot. Club **27**:261. 1900.

This it turns out is *R. digitatus* Hook., an untenable name, as it is antedated by *R. digitatus* Willd. *R. Jovis* will therefore have to stand for Hooker's plant.

Ranunculus platyphyllus (Gray), n. n.—*R. orthorhynchus platyphyllus* Gray, Proc. Am. Acad. **21**:377. 1886; *R. maximus* Greene, Bull. Torr. Bot. Club **14**:118. 1887.

There seems to be no good reason why Dr. Gray's name should have been rejected.

Saxifraga oregonensis (Raf.) n. n.—Diminutive perennials from a slender caudex: stems simple, 3–8^{cm} high, glandular-pubescent: the

leaves small, mostly basal, oblong-spatulate, minutely hispid-ciliate: flowers few, in a crowded glomerule at summit: calyx minutely glandular-pubescent, its whole tube adnate to the carpels: petals broadly obovate-cuneate, truncately rounded at summit, twice as long as the calyx lobes, distinctly divergently 3–nerved: the distended subglobose calyx-tube papillose-rugose from the pressure upon it by the numerous brown seeds within.

This is the rare and troublesome little alpine plant of the middle Rocky Mountains which has been referred to *S. adscendens* L., an arctic plant from which it seems to be distinct. The other names which it has also borne are *S. petraea* L. and *S. controversa* Sternb., both of which seem to refer to *S. adscendens* L., and are furthermore both encumbered by synonyms through their application to other very distinct species. Therefore it seems best to take up Rafinesque's name, under Ponista (*P. oregonensis* Raf. Fl. Tellur. **2**:66. 1836), as there can be no doubt as to its application to our plants.

SAXIFRAGA SUBAPETALA **normalis**, n. var.—Very similar to the species, but petals evident, elliptic-spatulate, as long as the calyx-lobes: as in the species the carpels are immersed in a crest-margined disk which persists at the middle of the mature carpels as an undulate ridge.

For the description of the species see Erythea **7**:169. 1899. This has been distributed by various collectors either as *S. integrifolia* or as *S. Sierrae*, from both of which it is quite distinct.

Parthenocissus laciniata (Planch.), n. comb.—*P. quinquefolia laciniata* Planch. in DC. Mon. Phan. **5**:449. 1887; *P. vitacea* (Knerr) A. S. Hitch., Sp. Fl. Man. 26. 1894.

Prunus ignotus, n. sp.—Shrubby or possibly becoming tree-like: branches slender, none of them becoming indurated or thorny: leaves glabrous from the first, simply and sharply serrate: flowers white, appearing with or after the leaves, solitary or 2–3 in a cluster: calyx turbinate; its lobes entire, glabrous within and nearly so without: petals obovate: fruit not known.

It is a little singular that no one has reported this in fruit, but the fine specimens distributed by Prof. *C. S. Crandall*, as *P. pennsylvanica*, from the banks of the Cache la Poudre, near Ft. Collins, Colo., May 1897, cannot well be ignored.

Philadelphus intermedius, n. sp.—A low branching shrub with dark green glabrous aspect: leaves short petiolate or subsessile,

broadly oval to ovate, rounded at base and either subacute or obtuse at apex, entire, glabrous or with some scattering ciliate hairs closely ciliate on the margins with short incurved hairs, 15–25^{mm} long: flowers medium size, a 3-flowered cyme from the terminal pair of leaves, a pair of flowers in the next pair of leaves, and sometimes another pair in the axils of the next lower pair of leaves—thus all the flowers except the terminal one are foliose-bracted: calyx glabrous, its lobes finely pubescent within: petals oval, about 12^{mm} long: stamens 30 or more: styles united for two-thirds of their length, the free portion as long as the abruptly enlarged stigmatic portion.

This is most nearly allied to *P. Lewisii* Pursh, from which its smaller size, smaller leaves, smaller flowers, and peculiar stigmas distinguish it. In *P. Lewisii* the styles are united throughout, the stigmatic portion as long as the style proper, the stigmatic line being broad and capping the summit of the stigma and then extending down to the styles in a narrowing line. *P. intermedius* seems to be a connecting species between the desert species of Utah and Colorado and those larger forms of the humid northwest.

Philadelphus nitidus, n. sp.—Slenderly and divaricately branched: leaves rather few, shining and with glaucous hue on both sides, nearly glabrous above, minutely appressed strigose below, mostly narrowly lance-oblong, subacute at both ends, very short petioled, 1–2^{cm} long: flowers generally solitary at the ends of the branchlets: calyx cleft below the middle, hirsute on the outside, soft pubescent on the inside of the lobes: petals elliptic, entire, 8–10^{mm} long, twice as long as the calyx lobes: stamens 30–40: styles distinct down to the ovary: stigmas short, slightly geniculate at junction with filament.

The following collections of this species are at hand: *H. N. Wheeler*, no. 425 (type), Sapinero, Colo., 1898; *C. F. Baker*, no. 266, Black Cañon, Colo., June 27, 1901; *M. E. Jones*, no. 6303, Belknap, Utah, June 28, 1899.

LARAMIE, WYOMING.

BRIEFER ARTICLES

ANTHOCEROS AND ITS NOSTOC COLONIES.

THE association of the liverwort Anthoceros with the blue-green alga, Nostoc, has long been known and has been studied with considerable care. The significance and value of this association have been speculated upon; but, as far as I know, no experiments on the subject have been reported. The anatomical relations of the two associates have been studied and described, but I do not know that cultures of Anthoceros from the spore on sterilized soil have been attempted. I shall here describe both the culture of Anthoceros, and, at the risk of some repetition of facts already recorded by others, the anatomical relations of the Nostoc to the surrounding tissue.

Anthoceros fusiformis Aust., and *A. Pearsoni* M. A. Howe fruit here abundantly in May. Their spores can then be collected almost or quite unmixed and free from the spores of other small plants, and may be kept air-dry for months. The dry season ordinarily lasts from mid-May to October, and during this time usually no rain falls. The spores germinate out of doors soon after the first abundant rain has thoroughy moistened the soil to a depth of several inches. The natural "resting-period" for the spores is, therefore, four or five months long, but the spores retain their vitality much longer. They may also be made to germinate in much shorter time. The "resting-period" seems to be, therefore, a matter of natural conditions rather than of transmitted habit.

The soil on which I grew plants from the spore was brought into the laboratory from the bank on which these plants, along with other small archegoniates, grow abundantly during each rainy season. After thorough air-drying, the soil was freed from pebbles, pulverized in a mortar, and put to a depth of a centimeter or slightly more in crystallizing dishes of thin white glass. These dishes were about 8^{cm} in diameter, 3.5^{cm} in depth, and were covered by the lids or bottoms of Petri dishes. These covers do not fit tightly; at the same time that they exclude dust and maintain the moisture of the air, they permit fair ventilation. The soil was invariably moistened from the beginning with boiled distilled water, for I wished to avoid any accumulations of salts in these undrained cultures from using our hard tap-water. These covered dishes were now divided

into two lots of equal number, one lot being put aside in the dark for a few days and the other steam-sterilized for two or three hours on three successive days. This sterilization proved thorough so far as blue-green algae are concerned, since none developed in the dishes. A certain amount of infection is unavoidable, and a few cultures in each lot had to be thrown away because of the development of some "damping-off" fungus. But on the whole the plants in my cultures have done quite as well as those out of doors. During the growing season now ending they did better than those out of doors, because November and December were cold and dry.

Eleven or twelve weeks after sowing, the small plants already bear archegonia and antheridia when the cultures are kept under suitable conditions of illumination. Cultures kept too dark will contain few if any fruiting plants, though the plants may be normally large. From this fact, though I have not attempted to support this view by further investigation, one may infer that light acts as a stimulus to the development of the reproductive organs as VÖCHTING[1] and KLEBS[2] have shown to be the case in certain flowering plants and fresh-water algae.

On comparing the young plants on sterilized and on unsterilized soil the greater size and more robust appearance of the plants on sterilized soil is evident. The plants on sterilized soil contained no Nostoc colonies. The plants on unsterilized soil contained Nostoc colonies, few of them bore reproductive organs, and they appeared less thrifty. But the young Anthoceros plants on unsterilized soil were obliged to compete not only with each other but with several other sorts also. Without attempting an exhaustive list of these other plants I may record the presence, in the cultures, of prothalli of *Gymnogramme triangularis*, fronds of *Fimbriaria Californica*, two or three small mosses, both protonemal and adult, some green algae (especially a small Vaucheria), some blue-green algae (Nostoc, Oscillatoria, Anabaena), chickweed, and grass. Besides these, which started from spores, seeds, or other resting stages, there were small plants which had held over the dry season as CAMPBELL[3] has described, fern prothalli and plants of Fimbriaria and Anthoceros.

Where young plants of Anthoceros have to compete in small cultures with such a number of individuals and of kinds of already fairly established plants, it is natural to assume that this amount of competition may

[1] VÖCHTING, H., Ueber den Einfluss des Lichtes auf die Gestaltung und Anlage der Blüthen. Jahrb. Wiss. Bot. **25**:149. 1893.

[2] KLEBS, G., Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. Jena, 1896.

[3] CAMPBELL, D. H., Resistance of drought by liverworts. Torreya **4**:81. 1904.

have much to do with their less thrifty appearance. However, the presence of Nostoc colonies on the soil does not necessarily imply the infection of all Anthoceros plants near them. As a matter of fact, a good many Anthoceros plants free from Nostoc can be found on unsterilized soil. These look better than those beside them containing Nostoc colonies, and as well as those in the dishes of sterilized soil.

Where cultures receive light mainly from the side, as is generally the case in a laboratory, Anthoceros plants, like fern-prothalli and the thalli of Fimbriaria, turn up from the surface of the soil, presenting their normally upper surface toward the window and bearing rhizoids on the shaded side. These plants necessarily contain fewer Nostoc colonies than those remaining flat on the soil, for the younger and elevated parts are less accessible to Nostoc filaments. Comparisons of older cultures than those just described shows that Anthoceros plants containing only one or two algal colonies are nearly or quite as thrifty as those with none, and are decidedly more vigorous than those with many.

PRANTL[4] attributed an advantage to Anthoceros from its association with Nostoc, on the ground that Nostoc might fix the free nitrogen of the air and contribute its products to the liverwort, but the weight of evidence seems now to be against the assumption that blue-green algae by and of themselves add at all to the combined nitrogen in the soil,[5] whatever the results of their association with N-fixing soil bacteria may be. The fact that, in my cultures at least, Anthoceros does better when free from Nostoc, removes all ground for PRANTL'S claimed advantage from the association so common in nature.

On the other hand JANCZEWSKI'S designation of the Nostoc colonies as parasitic[6] is not logically justified by my cultures or by the luxuriance in growth and by the fertility of these two species of Anthoceros in this region in ordinarily good seasons. Last year they throve as I never saw them before. This season has been by no means so favorable, dry weather having come long before the plants, held back by the cold and dryness of November and December, could ripen their spores in large numbers. All I feel inclined to say is that Nostoc certainly does not benefit Anthoceros, which in fact does better without it.

It is a matter of common observation that many blue-green algae

[4] PRANTL, K., Die Assimilation freien Stickstoffs und der Parasitismus von Nostoc. Hedwigia **28**:135. 1889.

[5] PFEFFER, W., Pflanzenphysiologie, 2te Auflage, 1:386–7, 393. 1897.

[6] JANCZEWSKI, A. DE, Vergleichende Untersuchungen über die Entwickelungsgeschichte des Archegoniums. Bot. Zeit. 377 ff. 1872.

thrive best where there are considerable quantities of organic matter.[7] It is conceivable that Nostoc profits from intimate association with green plants, but to prove the parasitic nature of such association is very difficult. I could not detect that the Nostoc cells, filaments, and colonies within the thallus of Anthoceros appear healthier, or larger, or grow more rapidly, than those on the moist earth near by. The cells of this and many other blue-green algae are so small and the organs of the cell so slightly differentiated that differences between cells are by no means noticeable. From the evidence at hand it is equally unsafe to say that Nostoc is or is not parasitic in Anthoceros.

Passing now to anatomical considerations, PRANTL[8] asserts that the characteristic development of the thallus cavities and the formation of internal hairs follows the entrance of Nostoc filaments only, not of any other small plants. The manner of infection I will not go into, for it has been repeatedly described.[9] The invading filament, if it survives, gives rise to a colony, spheroidal in form and enclosed in gelatinous matter which increases with the growth of the colony. Mechanical pressure, increasing with the growth of the colony and with the amount of water absorbed, is brought to bear against the surrounding cells of the thallus, enlarging the cavity which the Nostoc filament entered through one of the slime-slits on the surface. Another effect of the increasing pressure is the compacting of the immediately surrounding tissue. But because the Nostoc colony is not homogeneous, being in part cells and in part the gelatinous product of these cells, the pressure is not equal over all parts of the surface. The gelatinous matter between the filaments is softer and more readily penetrated or displaced than the filaments themselves. If small thallus cells lie opposite to and in contact with these gelatinous parts of a colony, they will necessarily be pushed forward by their neighbors. As has long been known, chains of cells, constituting the internal hairs above mentioned, do grow into the colonies and among the filaments of Nostoc. Other organisms, though they may enter the body of the liverwort, either do not exert any pressure at all, being smaller than the cavities they occupy, or form such compact masses that there is no chance for the surrounding cells to grow out as chains.

From this consideration of the structure and mechanics of the Nostoc colony, we are led to see the fallacy of PRANTL'S argument that, because

[7] See for example KIRCHNER, O., Schizophyceae in Engler & Prantl's Natürliche Pflanzenfamilien. I. 1[a]:48. 1898.

[8] PRANTL, K., *loc. cit.*

[9] CAMPBELL, D. H., Mosses and Ferns, Ed. 2, 128. New York, 1905.

cavities and hairs do not develop in the familiar way except where Nostoc colonies are, the liverwort must profit by such associates. It is simply a matter of mechanics. Where the resistance is less than growth can overcome (and this is the case between the Nostoc filaments in the gelatinous mass), the liverwort cells will grow out, forming short hairs. The growing and swelling colony as a whole will enlarge the cavity in which it lies. There are other intercellular spaces throughout the thallus, but these are not enlarged because not occupied. There is no conceivable advantage in their enlargement.—GEORGE J. PEIRCE, *Stanford University, California.*

DISTRIBUTION AND HABITS OF SOME COMMON OAKS.

SINCE writing the paper under this title, which appeared in the June number of this journal, I have been in Milwaukee and had the opportunity of examining the oaks in two herbaria, probably representative of any that may be found there. In the Public Museum were two specimens labeled *Quercus palustris* Du Roi. One had an acorn, and as far as determinable by this and the leaf-characters, was *Q. ellipsoidalis;* it is certainly *not* what it is labeled. The other was without fruit, and was doubtless the same species. In the herbarium of Dr. LEWIS SHERMAN, one of the older residents of Milwaukee and an acquaintance of Dr. LAPHAM, was a specimen labeled as above. It had an acorn cup but no nuts. This showed at least that it was *not Q. palustris.* All the evidence tends to the conclusion that the real pin oak does not occur in the region from which these specimens were taken.—E. J. HILL, *Chicago.*

CURRENT LITERATURE.

BOOK REVIEWS.

Evolution.

A COMPREHENSIVE account of the subject of evolution is at present a matter of considerable importance, but at the same time must be one of unusual difficulty because of the great activity incited by the work of DE VRIES and others who have within the last few years undertaken the study of variation, adaptation, and heredity by experimental methods. Dr. J. P. LOTSY[1] has undertaken this most difficult task by the publication of a volume of lectures upon theories of descent with special reference to the botanical side of the question. He follows the method not infrequent among older writers but rare among writers of recent scientific works, of beginning at the beginning. He first considers the nature of knowledge, and the supposed conflict between science and religion, pointing out that evolution will not explain everything, and that there is no conflict between religion and science except as either or both attempt to explain dogmatically the unexplainable. Both science and religion come to the same conclusion when traced to their limit, namely, that there is a fundamental mystery incapable of investigation because none of the possible alternatives is even conceivable to the human mind.

After these two introductory lectures, one lecture is devoted to evolution in general, beginning with the origin of the earth, the evolution of minerals, the origin of life, and the relation of form to environment. Two lectures deal with the morphogenic stimuli and the various theories of direct response and adaptation. The views of REINKE and KLEBS are contrasted, and those of LAMARCK, SPENCER, NÄGELI, and WARMING are compared. Here the author gives a well-deserved appreciation of the work of LAMARCK, though he is not himself in any proper sense a Lamarckian. The subject of heredity is considered in six lectures, dealing first with the older theories of SPENCER, DARWIN, NÄGELI, and WEISMANN, which were of a purely hypothetical nature, and then taking up the development of our knowledge of chromosomes as the bearers of heredity. One whole lecture is devoted to MENDEL and his laws, two to variation curves and GALTON'S laws of inheritance, and one to numerous subsidiary questions, such as dominance and blending, atavism, kryptomery, pleiotypy, half races, etc., and one to the inheritance of acquired characters.

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[1] LOTSY, J. P., Vorlesungen über Descendenztheorien mit besonderer Berücksichtigung der botanischen Seite der Frage, gehalten an der Reichsuniversität zu Leiden. Erster Teil. 8vo. pp. xii + 384. *pls. 2. figs. 124.* Jena: Gustav Fischer. 1906. *M* 8; geb. *M* 9.

Discontinuous variation and mutation are treated in three lectures, and the six remaining lectures trace the history of the evolution idea from ARISTOTLE to DARWIN, the last lecture being devoted to the life of the latter.

A treatise on contemporaneous science is fraught with the same difficulties as attend the writing of contemporaneous history. A just estimate of the importance of the latest developments in either case only becomes possible in the light of subsequent development, and consequently a book of this kind might be expected to have a very evanescent value. LOTSY has avoided very much of this by taking a judicial attitude and treating his subject historically. He has depended to a very large extent upon quotations from the various scientists whose views or results he has presented, and this gives the reader something of the unpleasant sensation always given by a so-called "digest;" but his choice of quotations is good and his own language is simple and direct, and therefore easily followed.

A second volume is promised, in which is to be indicated the work still to be done, and this will be awaited with much interest, for it will be here that we may hope to gain more of the personality of the author. The present volume is exceptionally impersonal, and both gains and loses by this fact. If the second volume takes on the strength and virility of personal enthusiasm which incites to investigation, the lack of such qualities in this first volume may not be looked upon as a disadvantage. But even if it should indicate in the same dispassionate manner that characterizes this book, the problems awaiting solution, he will deserve the gratitude of every biologist. While this book can not be said to *fill* the need that called it forth, it is gratifying that the first attempt at filling it is so excellent. As the first comprehensive work dealing with the more recent phases of evolutionary study it should at once gain a deservedly large circulation.—GEORGE H. SHULL.

Chemistry of plants.

THE second volume of CZAPEK'S *Biochemie der Pflanzen* is a huge one,[2] and deepens the impression made by the first volume of the immense labor which such a compilation represents, and the equally immense service which the author has rendered to science in its preparation. For knowledge of the chemistry of plants has lagged far behind that of animals, which, under the stimulus of human relations through medicine, has been under constant investigation by many students.

This volume is devoted to (1) the proteids and their metabolism in various plants (bacteria and fungi, mosses, algae, seeds, buds, leaves, roots, pollen grains) including the formation, absorption, and regeneration of proteids by various parts and under various conditions; (2) the nitrogenous end products of metabolism, including purin bases, glucosides yielding HCN, and alkaloids;

[2] CZAPEK, F., Biochemie der Pflanzen. Zweiter Band. 8vo. pp. xii + 1027. Jena: Gustav Fischer. 1905. *M* 25.

(3) respiration and its products; (4) coloring matters other than chlorophyll and its associates; (5) mineral constituents; and (6) substances produced by stimulation. At the close is an appendix of 21 pages with many supplementary notes and corrections, bringing the data down to June 1905. A complete index renders available the rich store of information summarized in the text, and gives thus a clue to the literature of any substance or the chemistry of any group of plants.

The work is rather more than its title indicates, since it is pervaded by a strong physiological flavor. The chapter on respiration, indeed, is almost as much physiological as chemical, though it deals chiefly with the quantitative relations of the oxygen fixed and the various end-products of "oxidation."

With this work as a convenient register of the work heretofore done in plant chemistry, the progress of knowledge in this field ought to be much accelerated. Even though no such chemical work is in progress, every botanical laboratory, whether in experiment station or college, and every chemical laboratory, in connection with its courses or work in organic chemistry, needs this book for reference; while for public libraries it is as indispensable as an encyclopedia.—C. R. B.

MINOR NOTICES.

Mosses.—The third part of GROUT'S *Mosses with hand-lens and microscope* contains the families Encalyptaceae, Orthotrichaceae, Funariaceae, Bryaceae, Leskeaceae, and some of their smaller allies.[3] The Orthotrichaceae and Bryaceae are particularly difficult groups, and the admirably reproduced illustrations from the *Bryologia Europaea* and SULLIVANT'S *Icones* (with an occasional original figure) will be most helpful to amateurs who cannot own these costly works. The keys are clear and concise. The text might easily be improved by being made more formal, with the chatty matters reduced to notes in smaller type under the appropriate headings. But the clientèle to whom the work is addressed will not quarrel with this—until they become increasingly expert and seek data for which the space might have been used but is not. Then it will be time for them to lay aside these useful crutches and take up the technical works. It is a marvel that the author can furnish such numerous and good illustrations and well-printed letter-press at the price.—C. R. B.

Sylloge Fungorum.—Volume XVIII, Part VII of the Supplement of that monumental work of taxonomic mycology, Saccardo's *Sylloge Fungorum*, has recently been issued (January 30, 1906). This volume contains additions bringing as nearly up to date as possible the compilation of descriptions of the Discomycetae, Myxomycetae, Myxobacteriaceae, and Deuteromycetae. The last group, which constitutes the *Fungi Imperfecti* of the older volumes, occupies fully

[3] GROUT, A. J., Mosses with hand-lens and microscope, a non-technical handbook of the more common mosses of the northeastern United States. Part III. Imp. 8vo. pp. 167–246. *pls. 36–55. figs. 79–133.* Brooklyn, N. Y. The Author, 360 Lenox Road. 1906. $1.25.

two-thirds of the present volume. The work concludes with the usual "repertorium," index of species, and a complete index of genera in all volumes. The generic index is printed on differently colored paper. Some suggestions regarding the diagnosis and nomenclature of species printed in the first pages of the volume aim to bring about some uniformity in the publication of species. As these rules have been published in several journals,[4] it is unnecessary to repeat them here.—H. HASSELBRING.

A book for young gardeners.—A booklet prepared by H. D. HEMENWAY,[5] the director of the School of Horticulture at Hartford, Conn., will prove helpful to those interested in home and school gardens. Aside from simple discussion of the objects and benefits of tillage, the preparation of the soil, and planting the garden, the booklet furnishes abundant and detailed directions for testing and saving the seeds of the more common flowers and vegetables, for the planting of trees, the making of hot-beds, the making of window gardens, and for the culture of strawberries and other fruits. The directions are clear and give with sufficient detail the points most useful to the beginner.—H. HASSELBRING.

Das Pflanzenreich.—Part 25 of this work has just appeared[6] and contains a presentation of the Juncaceae by the late Dr. FR. BUCHENAU. The usual full discussion of the various structures of the family and its geographical distribution is followed by a synopsis of the 8 genera, among which the species are distributed as follows: Distichia (3), Patosia (1), Oxychloe (2), Marsippospermum (3), Rostkovia (1), Prionium (1), Luzula (61, of which 2 are new), Juncus (209, of which 5 are new). The whole presentation is remarkably full in details of forms and in illustrations, and is of particular interest to American botanists.—J. M. C.

Index Filicum.—The ninth fascicle of CHRISTENSEN'S work has appeared,[7] carrying the references from *Polypodium Beddomei* to *Polystichum aculeatum*. The great genus Polypodium fills the whole fascicle excepting the last page.—J. M. C.

NOTES FOR STUDENTS.

Plant diseases.—CLINTON,[8] in his report as Botanist of the Connecticut Experiment Station for 1905, presents interesting notes and illustrations of several fungous diseases of plants in that state, followed by a more detailed

[4] In the United States, in Jour. Mycol. **10**: 109. 1904.

[5] HEMENWAY, H. D., Hints and helps for young gardeners, a treatise designed for those young in experience as well as youthful gardeners. 8vo. paper. pp. 59. illustrated. Hartford, Conn.: The Author. 1906. 35 cents.

[6] ENGLER. A., Das Pflanzenreich. Heft 25, Juncaceae by FR. BUCHENAU. 8vo. pp. 284. *figs. 121* (*777*). Leipzig: Wilhelm Englemann. 1906. *M* 14.20.

[7] CHRISTENSEN, C., Index Filicum, etc. Fasc. 9. Copenhagen: H. Hagerups Boghandel. 1906. *3s. 6d.*

[8] CLINTON, G. P., Report of the Botanist. Rept. Conn. Exp. Stat. **1905**: 263–330. *pls. 13–25. figs. 8–9.* 1906.

account of the downy mildew of the lima bean, due to *Phytophthora phaseoli*, and of the downy mildew or blight of the Irish potato, due to *Phytophthora infestans*. The two latter diseases are fully described and illustrated, and citations of the literature of each disease are given.

WHETZEL[9] gives an illustrated account of the following bean diseases found in New York state: anthracnose, due to *Colletotrichum lindemuthianum*; blight, due to *Bacterium phaseoli;* and rust, due to *Uromyces appendiculatus*. Methods of treatment are also given in each disease.

SHELDON[10] has just published the results of his study of the ripe rot or mummy disease of guavas. This disease is similar in many respects to the ripe rot or bitter rot of apples. It is produced by *Glomerella psidii* (G. Del.) Sheldon. He found the ascigerous stage and worked out the life history of the fungus in considerable detail.

NORTON[11] has published a brief summary of the present knowledge of the diseases of the Irish potato in Maryland together with methods of treatment of these diseases.

STEVENS[12] in his report as Biologist of the Experiment Station of North Carolina gives the results of his experiments in soil treatment for the prevention of the Granville tobacco wilt. He concludes that the greatest hope of overcoming this serious trouble lies in the breeding and selecting of resistant strains of tobacco, and he is now engaged in this line of work.

SMITH[13] presents preliminary observations regarding three serious diseases of tomatoes in California. The first is the damping off of the young seedlings. It is suggested that to check the spread of this trouble the plants and soil be sprayed with weak Bordeaux mixture followed with a sprinkling of sulfur. Soil sterilization by means of live steam would no doubt control it in cases where the application of this remedy is possible. The second disease mentioned is the summer blight, due to a species of Fusarium which attacks the plant in much the same manner as does the fusarium stage of Neocosmospora which causes the wilt of cotton, etc. The third disease mentioned is the winter blight, due to the potato-blight fungus, *Phytophthora infestans*. It occurs only after heavy fogs, dews, or rains, and hence in California attacks only the winter crop. Spraying with Bordeaux mixture is recommended to be applied just after the rains or dews.

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[9] WHETZEL, H. H., Some diseases of beans. Bull. N. Y. Cornell Exp. Stat. 239:195–214. *figs. 100–114.* 1906.

[10] SHELDON, J. L., The ripe rot, or mummy disease of guavas. Bull. W. Va. Exp. Stat. 104:299–315. *pls. 1–4. fig. 1.* 1906.

[11] NORTON, J. B. S., Irish potato diseases. Bull. Md. Exp. Stat. 108:63–72. *figs. 1–4.* 1906.

[12] STEVENS, F. L., Report of the Biologist. Rept. N. Car. Exp. Stat. **1904**: pp. 10. 1905.

[13] SMITH, R. E., Tomato diseases in California. Bull. Calif. Exp. Stat. 175: 1–16. *figs. 1–8.* 1906.

REED[14] has described three fungous diseases of the cultivated ginseng. These diseases are not due to the same fungi reported by VAN HOOK[15] as causing ginseng diseases in New York. The first of these is a stem anthracnose due to *Vermicularia dematium*. The second is a leaf anthracnose due to *Pestalozzia funeria*. These two diseases he finds may be controlled by spraying with the usual Bordeaux mixture. The third disease described is a wilt due to *Neocosmospora vasinfecta nivea*. This same variety causes a wilt disease of the watermelon, while the species itself causes a wilt disease of cotton and the cowpea. REED finds that the wilt never occurs except in association with or following an attack of the stem anthracnose. In other words, the wilt fungus seems to be able to gain entrance to the ginseng plant through the lesions on the stem due to this other stem disease. It is also possible that the wilt fungus enters the plant at the scar left where the stem of the preceding year fell off. It should be recalled in this connection that the cotton and cowpea wilt-fungus enters the host through the roots largely after injury by the nematode worm.—E. MEAD WILCOX.

SORAUER[16] describes a peculiar disease of *Cereus nycticalis* Lk. which results from proliferation of cells of the inner layers of the cortex. This produces on the stems slightly elevated hygrophanous areas which increase in size until they occupy a large part of the stem and extend to the wood. These turn brown and then black and finally collapse, leaving depressed wounds in the stem. On account of the position of the proliferating cells SORAUER designates these growths as "internal intumescences." The diseased regions are almost free from starch, but they are rich in glucose, which the writer regards as the cause of the unusual growth. This condition is brought about by high temperature and excessive moisture. When these factors were changed no "intumescences" were formed. —H. HASSELBRING.

The maturation mitoses.—A critical review of the entire subject of the maturation mitoses in both plants and animals has been prepared by GRÉGOIRE.[17] Part I, dealing with stages from the metaphase of the first mitosis in the mother-cell up to the telophase of the second division, contains 155 pages and 147 text figures, of which 35 pages and 35 figures relate to sporogenesis in plants, 90 pages and 112 figures to spermatogenesis and oogenesis in animals, and the remaining 30 pages to a comparative study. The space given to animal mitoses increases the value of the work to botanists, who are already more or less familiar with the botanical literature. At the close of the botanical section the conclusion

[14] REED, H. S., Three fungous diseases of the cultivated ginseng. Bull. Mo. Exp. Stat. 69:41–66. *figs. 1–9.* 1905.

[15] VAN HOOK, J. M., Diseases of ginseng. Bull. N. Y. Cornell Exp. Stat. 219: 163–186. *figs. 18–42.* 1904.

[16] SORAUER, P., Zeitr. Pflanzenkrankheiten **16**:5–10. *pl. 2.* 1906.

[17] GRÉGOIRE, VICTOR, Les resultats acquirés sur les cinèses de maturation dans les deux règnes. Premier mémoire. Revue critique de la littérature. La Cellule **22**:221–376. *figs. 147.* 1905.

is reached that the definitive chromosomes of the first mitosis constitute two branches which are variously placed with relation to each other. These two branches are the daughter chromosomes of the first mitosis. During the metaphase or anaphase these daughter chromosomes split longitudinally. In the telophase no complete spirem is formed nor do the nuclei reach the resting condition, but the chromosomes preserve their individuality so that the longitudinal portions which appeared in the anaphase of the first mitosis become the daughter chromosomes of the second mitosis. Consequently, the second mitosis cannot be a reduction division. Whether a reduction takes place at the first mitosis will be discussed in the second memoir. In the general résumé the conclusion is reached that in both plants and animals the definitive chromosomes of the first mitosis, at the equatorial plate stage, are composed of two continuous branches. There are two categories of theories as to the significance of the second mitosis, the one holding it as an equation division and the other as a reduction division.

In regard to the two constituent branches of the chromosomes of the first mitosis, there are two possibilities: if they are longitudinal pieces of a segment of a primary chromosome, the heterotypic division is an equation division; if, on the other hand, each of the two branches is a complete somatic chromosome, there is a true reduction in the WEIS MAN sense. The important question is, How are the chromosomes of the first mitosis formed? This will be the subject of the second memoir.

The work will be welcomed by cytologists, for the subject matter is well arranged and conflicting theories are impartially discussed. While the title indicates only a critical review of the literature, the work is something more, because so much botanical investigation has been done in the writer's own laboratory, and because even the zoological section has not been written entirely from the literature, but from the writer's own preparations and numerous preparations loaned by prominent investigators of animal cytology.—CHARLES J. CHAMBERLAIN.

Nova in hybrids.—As has been already noted[18] in these pages, TSCHERMAK found a large number of instances in which *nova* appeared in hybrid beans and peas, in very definite ratios which were readily related to the ordinary Mendelian ratio. These *nova* were explained by him as characters latent in one of the parental strains, but rendered patent by the energizing effect of the cross-fertilization. CORRENS has adopted[19] for similar *nova* in Mirabilis the hypothesis of CUENOT, which makes such new characters the result of the combined action of two or more pairs of units, the positive member of some or all but one of these pairs of units being invisible because of the absence of the other member of the combination. For example, an albino mouse bred with a brown mouse may produce black offspring, because the albino contains a unit which

[18] See BOT. GAZETTE **39**: 302. Apr. 1905.

[19] See BOT. GAZETTE **40**: 234. Sept. 1905.

has the power of changing the gray pigment to black, but this pigment-changing unit will remain invisible so long as the albino is bred only with other albinos.

Under this conception the *novum* is a compound character formed by the combination of equivalent units, instead of a hitherto inactive character rendered active by the stimulating effect of a foreign plasma. TSCHERMAK[20] now assents to the explanation of CUENOT and CORRENS as valid in certain cases, but still maintains that the *nova* of his *Pisum arvense*×*sativum* crosses and others cannot be so explained, because he found no cases in which the offspring were not *all* cryptomeric. TSCHERMAK's reference to the fact that the *nova* are frequently of atavistic nature, as lending support to GALTON's "law of natural inheritance," will scarcely be approved, since the explanation of CUENOT and CORRENS would bring these into agreement with typical Mendelian hybrids.

BATESON[21] has likewise adopted the explanation of CUENOT and CORRENS in the interpretation of *nova* in sweet peas and stocks which had been presented[22] in the Second Report to the Evolution Committee, as wholly out of harmony with Mendelian inheritance. These now constitute exceptionally good examples of characters which can only become manifest when two or more units act together. The statement is made that most of the five gametically distinct types which should appear among the white sweet peas and white stocks of these crosses have been recognized, thus answering satisfactorily, in respect to these two species, TSCHERMAK's contention that the extracted whites were still cryptomeric.

The same explanation is clearly valid for the case reported by CASTLE[23] in which a white guinea-pig crossed with red gave rise to some black offspring, while the "extracted" whites from this cross, when crossed with red, produced no black young.—GEORGE H. SHULL.

Welwitschia.—The full paper on *Welwitschia mirabilis* by PEARSON has now appeared,[24] the abstract of last November having been noted in this journal.[25] The region of this strange plant is so difficult of access that Professor PEARSON is to be commended for the unusual efforts he has put forth to secure material. As it happened, the war in Africa has seriously interfered with his work, so that he was able to secure material of only one day's collecting, but he hopes that when the country becomes more settled he will be able to fill in the gaps.

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[20] TSCHERMAK, E., Die Mendelsche Lehre und die Galtonsche Theorie vom Ahnenerbe. Arch. f. Rass. u. Gesells. Biol. **2**:663–672. 1905.

[21] BATESON, W., SAUNDERS, E. R., and PUNNETT, R. C., Further experiments on inheritance in sweet peas and stocks: Preliminary account. Proc. Roy. Soc. London B. **77**:236–238. 1905.

[22] See BOT. GAZETTE **40**:313–314. 1905.

[23] See BOT. GAZETTE **40**: 385. 1905.

[24] PEARSON, H. H. W., Some observations on *Welwitschia mirabilis* Hooker. Phil. Trans. Roy. Soc. London B. **198**:265–304. *pls. 18–22.* 1906.

[25] BOT. GAZETTE **41**:226. 1906.

The plant is of such unusual interest that his results deserve rather full statement.

The maximum age attained by individual plants is probably much greater than a century; and plants growing in contact readily form natural grafts, into the composition of which several individuals may enter. Pollination is effected, partly, at least, by insects. The development of the spores and of the embryo proceed with remarkable rapidity for a gymnosperm. Microsporogenesis resembles that described for Ephedra and Gnetum; and at dehiscence three nuclei are found in the pollen grain, one of which, probably prothallial, disappears before shedding. The single megaspore mother cell forms the usual linear tetrad, the innermost spore functioning. In the germination of the megaspore there is abundant free nuclear division, and a strong growth of the sac towards the micropyle and into the chalazal region. The formation of cell walls occurs throughout the embryo sac, the cells thus formed often being multinucleate. Each peripheral cell towards the micropyle, containing two to five nuclei, produces a tubular outgrowth which penetrates the nucellar cap like a pollen tube. As this tube advances the nuclei pass into it, and the distance traversed before pollination occurs is considerable. These free nuclei are sexual, and hence the condition is that of Gnetum. These tube-forming cells have been taken for archegonium initials, but it is evident that the tube is only an extension of the prothallium containing free sexual nuclei; and hence PEARSON rightly calls it the "prothallial tube." This is a most satisfactory disposition of a troublesome structure; and we find that in the act of fertilization Welwitschia is even more specialized than is Gnetum.

It is to be regretted that the first stages of embryo-formation were not shown by the material, for the current statements in reference to it are as obscure and meaningless as have been those in reference to the so-called "archegonium initials."—J. M. C.

Mendelism in agriculture.—No other single scientific proposition has elicited so much interest from agriculturists and breeders as MENDEL'S laws of inheritance, and the number of more or less satisfactory popular presentations has become large. Several of these have already been noted. TSCHERMAK[26] adds another in a lecture before the German Agricultural Society, in which particular attention is given to the results in the breeding of cereals. Besides the general explanation of Mendelism, he gives tables showing what characters of the several cereals have been found dominant and what recessive. These tables include sixteen pairs of characters in wheat, five in rye, thirteen in barley, and three in oats. A short section is devoted to the technic of crossing, and another to the importance of establishing stations and properly equipping them for carrying on such investigations.

[26] TSCHERMAK, E., Die Kreuzung im Dienste der Pflanzenzüchtung. Jahrb. Deutsche Landw. Gesells. **20**:325–338. 1905.

HALSTED[27] has also issued a bulletin which gives a good general discussion of Mendelism as exemplified by cooperative experiments in the breeding of corn. In 1904 "Black Mexican" sweet corn was crossed with nearly a full list of the commercial varieties of sweet corn, and the hybrid ears thus obtained were sent to a number of volunteer observers in different parts of the state, who returned samples and notes which are incorporated into this bulletin. The presentation is simple and easily understood, but several unfortunate typographical errors are likely to prove confusing, as when on p. 15 in the table showing what may be expected in the second generation of a cross between large grained flint black, and small grained sweet white, the fourth category (large sweet white) is weighted with the value 9 instead of 3; and again, when on p. 21, line 7, "white" is used for "dark."

An improper emphasis is laid upon the difficulty of freeing the dominant form from traces of the recessive. Thus, he says that after nineteen generations of selection there will still be one recessive grain in each four hundred, adding that "this underlying rule," which appears to hold more or less closely, helps to indicate how difficult it is to eradicate entirely any characteristic that has been introduced in breeding." He seems to have overlooked the importance of VILMORIN'S principle of isolation, by which it requires only one more generation to obtain pure extracted dominants than extracted recessives, so that after the *third* generation he need never have another recessive grain appear.—GEORGE H. SHULL.

Inheritance in Shirley poppies.—PEARSON and his associates, with the aid of a number of volunteer observers, have presented a second paper[28] on inheritance in the Shirley poppy. Some of the questions that were left open in the earlier report[29] have been settled. Thus, it was assumed that Shirley poppies both self- and cross-fertilize, and the discussions were based upon that assumption. It is now found that when flowers are enclosed in bags of bolting-cloth or oiled paper, almost no fertilization takes place. Fifty bagged flowers produced seeds in only four, and these gave rise to nine plants. The conclusion is reached, therefore, that seeds taken from unprotected capsules are essentially the result of cross-fertilization; and the correlation of offspring with each other and with their antecedents should be the same as in other populations in which self-fertilization does not occur, as in animals and man. Although the correlation found is somewhat lower than the average for animals, a number of modifying factors are pointed out which would tend to lessen the correla-

[27] HALSTED, B. D., Breeding sweet corn—cooperative tests. N. J. Agr. Exp. Sta. Bull. 192. pp. 30. *pls. 4, figs. 8.* March 1906.

[28] PEARSON, K., et al., Cooperative investigations in plants. III. On inheritance n the Shirley poppy. Second Memoir. Biometrika 4:394–426. 1 *pl.* (colored). 1906.

[29] PEARSON, K., et al., Cooperative investigation in plants. I. On inheritance n the Shirley poppy. Biometrika 2:56–100. 1902.

tion, and the opinion is expressed that there is no reason to believe that the strength of inheritance is any different in Shirley poppies from that in animals.

Another gain is seen in the recognition of the entire plant as the hereditary unit, instead of the separate flowers, the latter view having been maintained in the earlier paper.

The characters used were the number of stigmatic bands, number of petals and petaloid stamens, color of petals, presence of a margin, presence of a basal spot and its color, and wrinkling of the petals. Each of these characters was divided into a number of categories designated in a manner that makes the personal equation a very large factor, *e. g.* with reference to the presence of a basal spot, the classes are "none, none to slight, slight, slight to well-defined, well-defined, well-defined to large, large." The observers found these categories very difficult to separate, and think there is no evidence of allelomorphic characters. They believe that the same is true in many studies made by those who accept MENDEL'S laws of inheritance. It need scarcely be pointed out that seeds secured from unguarded flowers from a field as heterogeneous as one of Shirley poppies could hardly be expected to show evidences of allelomorphic characters.—GEORGE H. SHULL.

Drying of seedlings and sporelings.—RABE finds that germinated seeds and spores resist drying more or less well.[30] With advancing germinative stages and exhaustion of reserve food the resistance to drying diminishes. Seedlings will withstand much longer drying in the air than in a sulfuric acid desiccator. The separated hypocotyl of a seedling always dies upon being fully dried out. The cotyledons are more resistant than the plumule, and of the latter the growing point and the axillary buds are more resistant than the leaves. The separated and dried portions of the seedling, if they are yet alive, are as vigorous in reproducing as the separated portions of the fresh seedling. In spite of the defective storage and marked shrinkage, the seedling of the unripe seed will withstand drying nearly as well as the seedling of the ripe seed. Seedlings of xerophytes are more resistant to drying than those of hydrophytes. The presence of the seed coat is a disadvantage to the dried seedling. Rapid admission of water is more advantageous to the dried seedling than slow admission. Seedlings of related species show no relation in their power to withstand drying. Water-free chemical reagents, as alcohol and benzene, act more harmfully on germinated dried seedlings than on ungerminated dried seeds. The germinated dried as well as the ungerminated soaked seeds are more injured by diluted than by concentrated glycerin. The longer the glycerin acts the greater the injury. The germinated spores of mosses are extremely resistant to drying whether in the air or in a sulfuric acid desiccator. Germinated spores of ferns and liverworts withstand but little drying. The power of plants to withstand drying depends mainly upon the peculiar properties of their protoplasm.—WM. CROCKER.

[30] RABE, FRANZ, Ueber die Austrocknungsfähigkeit gekeimter Samen und Sporen Flora **95**:253–324. 1905.

Anatomy of Cyperaceae.—The comparative anatomy of the Cyperaceae has been studied by PLOWMAN,[31] and as usual the chief interest centers in the stem. Amphivasal bundles are found throughout the rhizomes of all large-leaved species and at the nodes of aerial stems; elsewhere the bundles are collateral. The amphivasal bundles arise through the introduction into the node of the numerous leaf-trace bundles, and are independent of the branching of the stem. Hence the leaf is to be regarded as the dominant factor in the development of the stelar characteristics of the family and probably of the other monocotyledonous families. The course of the bundles in the rhizome approaches the "palm type," but in the culm the leaf-trace bundles pass down as cortical bundles through one internode and then fuse with the bundles of the central cylinder by a ring-like amphivasal plexus. The seedling and in some cases the floral axis show a simple tubular stele, which is to be regarded as the primitive condition, in contrast with the medullary and amphivasal bundles occurring in many parts of the plant. A cambium is present in the bundles at the nodes of *Scirpus cyperinus* and other species. These features indicate that the Cyperaceae is one of the more primitive groups of monocotyledons, though showing signs of specialization and reduction, accompanied by a high degree of anatomical unity. The view which derives the monocotyledons from an essentially dicotyledonous ancestry receives further support. The author proposes a division of the family into "Amphivasae" and "Centrivasae;" he also gives a key to the genera, based on anatomical characters. The paper is accompanied by a number of excellent photomicrographs.—M. A. CHRYSLER.

Origin of Cycadaceae.—WORSDELL[32] has published a *résumé* of his views as to the origin of the Cycads from the Pteridosperms, with full bibliography. The part dealing with the origin of axial structures is of greatest interest; and the thesis is that the Medullosan ancestry is clear. It is claimed that the cotyledonary node and the axis of the strobilus are the two principal regions for revealing ancestral characters. Much stress is laid upon MATTE's discovery of polystely in the cotyledonary node of *Encephalartos Barteri;* and also upon the very irregular orientation of the bundles of the peduncle of Stangeria. According to the author's view, the endarch cylinder of Lyginondedron and of the Cycads is of polystelic origin, coming from Medullosan ancestors, each constituent bundle being the homologue of the single bundle of the monostelic Heterangium. The endarch condition arises from the degeneration of the internal vascular tissues. Numerous illustrations are given, intended to show how the various vascular structures of both Pteridosperms and Cycads suggest this view and are most easily explained by it. The whole presentation is

[31] PLOWMAN, A. B., The comparative anatomy and phylogeny of the Cyperaceae. Annals of Botany **20**:1–33. *pls. 1–2.* 1906.

[32] WORDSELL, W. C., The structure and origin of the Cycadaceae. Annals of Botany **20**:129–159. *figs. 17.* 1906.

particularly valuable in bringing scattered data together in compact form, although opinions may vary as to their interpretation.

A new term of classification is introduced with "Cycadophyta," used to include Pteridosperms (Cycadofilices), Bennettitales, and Cycadales. The author also discredits somewhat the value of the ontogeny of the vascular structures as indicating their phylogeny.—J. M. C.

Osmosis and osmotic pressure.—A revolutionary paper upon the nature of osmosis and osmotic pressure has been published by KAHLENBERG,[33] who gives detailed accounts of his experiments. He shows clearly that whether osmosis will take place or not depends upon the specific relations between the septum and the liquids bathing it. If osmosis occurs these relations determine the magnitude of the pressure and the direction of the main current. There is, he claims, no such thing as a strictly semipermeable membrane, since a minor movement in the reverse direction always occurs, though it is often insignificant or practically negligible. The force concerned in osmotic processes lies not merely in the specific affinities between the solvent and the solutes, but primarily in their relation to the membrane, whether it be called "potential energy of solution," "internal pressure," or (as KAHLENBERG prefers) "chemical affinity." In measuring osmotic pressures (for which he devised a new apparatus), stirring the liquids is absolutely essential—a factor not previously reckoned with; and in his experiments these measurements show such unlike pressures with the same substances when different membranes are used, and such changes with different temperatures that he holds them irreconcilable with the theory that, as a general rule, solutes conform to the behavior of gases, however closely some in water may do this. The paper deserves the closest attention from every physiologist; yet the weighty evidence against KAHLENBERG'S conclusions must not be forgotten.—C. R. B.

The vitality of buried seeds.—DUVEL gives a preliminary account of experiments on the vitality of buried seeds,[34] of some of the common economic plants and weeds of the United States, representing 109 species, 84 genera, and 34 families. In December, 1902, eight to twelve lots of each species of seeds were buried at three depths: 15–20, 46–56, 90–105 cm. A sample of each is to be taken up at given periods and tested for vitality along with controls stored in a dry place.

Tests up to date show the following results. In some cases none of either the controls on the buried seeds grow. Among these are: *Axyris amaranthroides*, *Bursa bursa-pastoris*, *Polygonum pennsylvanicum*, *P. persicaria*, *P. scandens*.

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[33] KAHLENBERG. L., On the nature of the process of osmosis and osmotic pressure, with observations concerning dialysis. Journ. Phys. Chem. 10:141–209. 1906. Published also in Trans. Wis. Acad. 15:209–272. 1906.

[34] DUVEL, J. W. T., Vitality of buried seeds. Bureau Plant Industry Bull. 83. pp. 22. *pls.* 3. 1905.

A second group, among which are the common cereals and various other plants, as *Lactuca sativa, Helianthus annuus, Asparagus officinalis, Pinus virginiana, Robinia pseudacacia*, either all decayed before germinating or germinated and then all decayed before being examined. A third group, which includes our more noxious weeds, retained their vitality to a considerable degree. The deeper the seeds were buried the better they retained their vitality. Vitality is best preserved, even in weed seeds, when they are carefully harvested and stored in a dry and comparatively cool place.—WM. CROCKER.

Prothallia and sporelings of Botrychium.—BRUCHMANN[35] has been investigating *Botrychium Lunaria*. Since this species has no means of vegetative multiplication, like the adventitious shoots of *Ophioglossum vulgatum*, every sporophyte must have come from a gametophyte. The prothallia are hard to find because they are very small (1–2^{mm} long and 0.5–1^{mm} wide), and the sporelings grow for several years before they reach the surface of the soil. The prothallia are found at a depth of 1–3^{cm}. In form and general character the prothallium of *B. Lunaria* resembles that of *B. virginianum*, except that it is much smaller. BRUCHMANN succeeded in germinating the spores and his results agree with those of CAMPBELL, who got the two and three-cell stage in *Ophioglossum vulgatum*. Further work upon this aspect of the problem will be published later. However, he represents a single cell at the "spore pole" of the prothallium and regards this as the first cell of the prothallium, representing the protonema stage. Nearly every prothallium bears an embryo and some prothallia have two. The first division of the embryo is transverse. Growth is very slow, the sporeling being three years old before it reaches the surface. One plate and considerable attention in the text is devoted to the anatomy of the mature plant.—CHARLES J. CHAMBERLAIN.

Spermatozoids of Cycas revoluta.—MIYAKE[36] studied the living spermatozoids at the island of Oshima (28° 30′ N) in September, and in southern Japan (31° 35 N) from the beginning to the middle of October. The diameter of the spermatozoids varies from 180 to 210 μ. The two spermatozoids are surrounded by a delicate membrane, but it could not be determined with certainty whether the membrane belongs to the spermatozoid or is merely the *Hautschicht* of the protoplasm of the pollen tube. For observing the movements the spermatozoids were placed in a 10 per cent. cane sugar solution. The movements often continued for one to three hours; and in one case for six hours and forty minutes, and in another case for five hours and thirty minutes. In some cases the spermatozoids were shot out suddenly from the pollen tube, which seems to be the method that occurs under natural conditions. The forward movement is always accompanied by a rotation from left to right about the

[35] BRUCHMANN, H., Ueber das Prothallium und die Sporenpflanze von *Botrychium Lunaria* Sw. Flora **96**:203–230. *pls. 1–2.* 1906.

[36] MIYAKE, Ueber die Spermatozoiden von *Cycas revoluta*. Ber. Deutsch. Bot. Gesell. **24**:78–83. *pl. 6.* 1906.

axis. In some cases the forward movement was found to be at the rate of 0.7^{mm} per second. MIYAKE agrees with WEBBER that the liquid in the archegonial chamber at the time of fertilization comes from the pollen tube and not from the archegonium.—CHARLES J. CHAMBERLAIN.

Heterostyly and gynodioecism.—Inheritance of dimorphism has been investigated by RAUNKIÄR[37] in Primula, Menyanthes, Pulmonaria, Fagopyrum, Knautia, and Thymus. In all heterostylic species studied he finds that the long-styled and short-styled forms occur in about equal numbers regardless of the character of the environment. In gynodioecious species, on the other hand, he finds considerable variation in the proportions of the two forms in different localities. The results of breeding are in close accord with those of CORRENS,[38] except in an interesting case in which a cross between two bisporangiate plants of *Thymus vulgaris* produced 65 per cent. pistillate plants. In *Primula officinalis*, brachystylic plants pollinated by brachystylic produced 62.5 per cent. brachystylic, brachystylic×dolichostylic gave 55.2 per cent. brachystylic, and dolichostylic×dolichostylic only 4.3 per cent. brachystylic. Investigation covering several generations is needed to determine the effects of the pre-parental ancestry, and until this is done, any speculation as to the hereditary nature of the forms of a dimorphic species can be of little value.—GEORGE H. SHULL.

Development of spores of Helminthostachys.—BEER[39] has investigated the development of the spores of H. *zeylanica*, his material being fertile spikes preserved in spirit. CARDIFF,[40] and afterwards STEVENS,[41] had described the peculiar blocking out of the sporogenous tissue and the remarkable behavior of the plasmodium-like tapetal cytoplasm in Botrychium; and BEER finds the same phenomena in Helminthostachys. His observations extend, however, to the specific work of the tapetal plasmodium in spore-formation. The observed facts are that during the period of exospore growth the tapetal plasmodium shows more or less complete disappearance of starch, gradual diminution of the finely vacuolar cytoplasm, and richly chromatic nuclei which often show irregularities of outline. The conclusion is that the tapetal plasmodium is the center of metabolic activities in which a substance is elaborated from the raw materials contained in the tapetum, and is employed, directly or indirectly, in the growth of the spore wall.—J. M. C.

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[37] RAUNKIÄR, C., Sur la transmission par hérédité dans les espèces hétéromorphes. Bull. Acad. Roy. Sci. et Let., Denmark, pp. 31–39, 1906.

[38] See BOT. GAZETTE **39**: 304. 1905. and **41**: 302. 1906.

[39] BEER, RUDOLF, On the development of the spores of *Helminthostachys zeylanica*. Annals of Botany **20**:177–186. *pls. 11–12.* 1906.

[40] BOT. GAZETTE **29**:340–347. *pl. 9.* 1905.

[41] Annals of Botany **19**:—. —. 1905.

Seedlings of Piperales.—In continuing his work on the structure of the seedlings of certain Piperales, HILL[42] has published results dealing chiefly with several species of Peperomia. The transition phenomena are described in detail; that is (in brief), the arrangement of the vascular tissues in the cotyledonary or primary node, the transition region between root and stem, where the earliest tissues of the vascular system arise. The conclusion in reference to the primitive or reduced character of Peperomia is confirmatory of JOHNSON'S view that it is a reduced genus, the determining factor in reduction possibly being the epiphytic habit of many forms. It is also suggested that these transition phenomena may not be such important phylogenetic criteria as has been assumed by some investigators, since they do not seem to be sufficiently rigid to withstand the influence of varying conditions.—J. M. C.

Antipodal cells.—In a long article LOTSCHER[43] discusses the structure and function of the antipodal cells of angiosperms. On the basis of their anatomy and physiology he finds three types of antipodals: (1) those remaining as naked protoplasts or free cells and functioning in the resorption of the nucellus (Orchidaceae, Cruciferae, Geraniaceae, Linaceae, Papilionaceae, Primulaceae, Polemoniaceae, and Scrophulariaceae); (2) those well differentiated and forming a roundish cell-complex which serves to transform the foodstuffs which are brought to the embryo-sac (Gramineae, Araceae, Ranunculaceae, Mimosaceae, Cesalpinaceae, and in combination with the third type, predominant in Liliaceae, Iridaceae, Zingiberaceae, Borraginaceae, and Solanaceae); (3) those, singly or together, having an elongated form and functioning principally as haustoria (most Rubiaceae).—CHARLES J. CHAMBERLAIN.

Mechanics of secretion.—This problem has been attacked by LEPESCHKIN, who finds[44] that from "unicellular" plants (Pilobolus, Mucor, Phycomyces, and Vaucheria are so called), as well as from the epidermal structures of green plants, secretion is to be referred to the unlike permeability for solutes of the plasma membrane in the absorbing and secreting regions of the structure. The process of secretion and the influence of external agents upon it agree completely with the mathematical formulae for the energy involved, based upon the current theories of osmotic pressure. The permeability of the membrane is easily altered by external and internal influences. Whether this is characteristic of all semipermeable membranes or only of plasmatic membranes remains to be determined. The research adds some facts but leaves much yet to be explained regarding the subject.—C. R. B.

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[42] HILL, T. G., On the seedling-structure of certain Piperales. Annals of Botany **20**:160–175. *pl.* 10. 1906.

[43] LOTSCHER, P. KONRAD, Ueber den Bau und die Funktion der Antipoden in der Angiospermen-Samenanlage. Flora **94**:213–262. *pls.* 1–2. 1905.

[44] LEPESCHKIN, W. W., Zur Kenntniss des Mechanismus der aktiven Wasserausscheidung der Pflanzen. Beihefte Bot. Cent. **19**:409–452. 1906.

Pollen grains of Picea.—POLLOCK[45] has described variations observed in the pollen grain structures of *Picea excelsa*, chiefly in reference to the so-called prothallial cells. The usual number of these cells reported for the Abietineae is two, but POLLOCK finds the variation in Picea to range from one to three, with one as the number in the majority of cases. This is an interesting situation, as these cells have been reported thus far for the conifers only among the more primitive Abietineae and Podocarpeae, and it shows that even here they are in a very fluctuating condition. The condition among the Araucarias, recently announced by THOMSON, is interpreted as representing a still greater multiplication of prothallial cells, an interpretation that is probably justified. That among the conifers all stages in the elimination of this tissue are represented seems evident.—J. M. C.

Sclerotinia on Forsythia.—OSTERWALDER[46] has described a disease of species of Forsythia induced by *Sclerotinia Libertiana* which has heretofore been reported only upon herbaceous plants. The fungus infects the shoots of Forsythia only through the withering flowers, and extends up and down the woody branches from those points, causing a wilting of the twigs alone. Sclerotia are formed abundantly on the infected parts and after being kept over winter produce the typical apothecia of Sclerotinia. Spores or mycelium grown therefrom produced the disease anew when placed on the floral parts. Although Botrytis conidiophores occurred on some of the withered flowers, the author was able to show that these were not connected with the Sclerotinia, thereby supporting the view that *Sclerotinia Libertiana* has no conidial form.—H. HASSELBRING.

A sterile Bryonia hybrid.—In studying the development of the sex organs of a sterile hybrid of *Bryonia alba* and *B. dioica*, TISCHLER[47] comes to the conclusions that the absolute sterility has nothing to do with the tetrad formation because the megaspore series shows the normal tetrads, and that while there are irregularities in the formation of pollen there are also cases in which normal pollen is formed. It is possible that the cause of sterility in hybrids is more complicated than has been supposed. This work does not support the theory that sterility is due to total or partial loss of power by the male or female chromosomes. It may be that the sterility is due to a low nutrition of the protoplasm. It seems probable that the cause of sterility can best be investigated by combining culture methods and cytology.—CHARLES J. CHAMBERLAIN.

Photosynthesis.—USHER and PRIESTLEY have contributed strong support to the theory of BAEYER that formaldehyde is the first product of photolysis of CO_2.

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[45] POLLOCK, JAMES B., Variations in the pollen grain of *Picea excelsa*. Amer. Nat. **40**:253–286. *pl. 1.* 1906.

[46] OSTERWALDER, A., Die Sclerotienkrankheit bei den Forsythien. Zeitsch. Pflanzenkr. **15**:321–329. *pl 5.* 1905.

[47] TISCHLER, G., Ueber die Entwicklung der Sexualorgane bei einem sterilen Bryonia-Bastard. Ber. Deutsch. Bot. Gesell. **24**:83–96. *pl. 7.* 1906.

They find[48] an enzyme in spermatophytes and pteridophytes generally, which decomposes H_2O_2 energetically, with the evolution of O_2. When this enzyme is destroyed or its action inhibited, the chlorophyll is quickly destroyed and the plant bleached. They also demonstrated the formation of formaldehyde (when its prompt condensation was prevented) in the immediate vicinity of the chloroplasts. The usual condensation of the HCOH is due, they hold, to the protoplasmic stroma of the chloroplast and not to an enzyme; yet the experiment on which they rely is not conclusive on this point.—C. R. B.

Seeds of Euphorbiaceae.—A study of the development of the seeds of numerous genera and species of Euphorbiaceae has given SCHWEIGER[49] the following results: The obturator, a tissue which serves for the conduction and nutrition of the pollen tube, is always present. It disappears gradually after fertilization, leaving only a slight remnant which belongs to the placenta and never to the seed. The tip of the nucellus is often much elongated, and until fertilization is effected is often in direct connection with the obturator. The caruncle belongs to the seed, is developed from the outer integument, and serves to separate the seed from the placenta.—CHARLES J. CHAMBERLAIN.

Zygospores of Mucor.—According to HAMAKER[50] the production of zygospores of *Mucor stolonifer*, with proper conditions of moisture and temperature, is dependent only upon the nature of the substratum. The atmosphere should be saturated with moisture and the temperature about 70° F. The substratum used is corn muffin bread, which the baker makes after the following formula: corn meal, 16 pounds; flour, 3 pounds; lard, 3 pounds; salt, ½ pound; eggs, 48; sweet milk, 3 gallons; baking powder, 18 ounces. In a large proportion of cultures zygospores appear in five to seven days.—CHARLES J. CHAMBERLAIN.

Germination of pollen.—JOST has succeeded in germinating the pollen grains of various grasses,[51] which have heretofore proved refractory, by growing them under conditions where they can obtain water very slowly from the medium by which it is held. Thus, a starch paste made with only one or two parts of water proved useful; and also parchment paper soaked with a sugar solution. The pollen grains of certain Compositae have also yielded to the latter treatment, but none of the Cichoriaceae or Umbelliferae.—C. R. B.

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[48] USHER, F. L., and PRIESTLEY, J. H., A study of the mechanism of carbon assimilation in green plants. Proc. Roy. Soc. London B. **77**:369–376. 1906.

[49] SCHWEIGER, JOSEPH, Beiträge zur Kenntniss der Samenentwickelung der Euphorbiaceen. Flora **94**:339–379. 1905.

[50] HAMAKER, J. I., A culture medium for the zygospores of *Mucor stolonifer*. Science N. S. **23**:710. 1906.

[51] JOST, L., Zur Physiologie des Pollens. Ber. Deutsch. Bot. Gesells. **23**:504–515. 1906.

Dry rot.— BULLER[52] describes the destruction of pine paving blocks in Birmingham, England, by *Lentinus lepideus* Fr. This fungus produces a dry rot which in its microscopic and chemical aspects resembles the destruction of wood by *Merulius lachrymans*. Cellulose is removed from the walls and hadromal is left behind. The ravages of the fungus were somewhat checked by a dipping in creosote which the blocks had received before being laid down. —H. HASSELBRING.

Self-digestion of endosperm.—POND summarizes[53] the literature on this point, and finds no clear proof that the amylaceous endosperm of grasses or the horny endosperm of palms is capable of self-digestion, though this has been claimed by authors and the claim has been accepted hitherto. He himself carefully tested this point in the seed of the date, *Phoenix dactylifera*, and finds its endosperm incapable of self-digestion.—C. R. B.

Formation of chlorophyll.—According to PALLADIN this is a process of oxidation, dependent upon the presence of sugar solutions of low concentration (10%); but ISSATCHENKO reports[54] that chlorophyll formation depends only on the energy of light, occurs in conditions deemed unfavorable by PALLADIN, and is not inhibited by concentrations of even 30–50 per cent. sugar in detached leaves of *Vicia Faba*.—C. R. B.

Caprification.—LONGO has been investigating the fig and caprifig, and in advance of the full memoir with illustrations has published a brief preliminary announcement.[55] As the differences from previous accounts are those of detail rather than fundamental in character, a review will be deferred until the appearance of the full paper.—J. M. C.

Anatomy of Epigaea.—The histology of the stem and leaf are described in a paper by ANDREWS.[56] The most noteworthy point is the occurrence of glandular hairs on the lateral branches, and the suggestion is made that these aid in absorption of food.—M. A. CHRYSLER.

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[52] BULLER, A. H. REGINALD, The destruction of wooden paving blocks by the fungus *Lentinus lepideus* Fr. Jour. Economic Biol. **1**:1–12. *pls 1–2*. 1905.

[53] POND, R. H., The incapacity of the date endosperm for self-digestion. Annals of Bot. **20**:61–78. 1906.

[54] ISSATCHENKO, B., Sur les conditions de la formation de chlorophylle. Résumé. Bull. Jard. Imp. Bot. St. Petersb. **6**:27. 1906.

[55] LONGO, B., Ricerche sul fico e sul caprifico. Rend. Accad. Lincei **15**:373–377. 1906.

[56] ANDREWS, F. M., Die Anatomie von *Epigaea repens* L. Beih. Bot. Cent. **19**: 314–320 *pls. 6–8*. 1905.

NEWS.

DR. W. W. ROWLEE, Cornell University, has been advanced to a full professorship of botany.

DR. C. F. HEGELMAIER, professor of botany at the University of Tübingen, has died at the age of 72 years.

PROFESSOR L. M. UNDERWOOD, Columbia University, has received the degree of doctor of laws from Syracuse University.

DR. FRANZ BUCHENAU, the well-known monographer of Junaceae, died at Bremen, April 23, at the age of seventy-five years.

THE GERMAN BOTANICAL SOCIETY has offered a prize of 1000 marks for a monograph on polymorphism in the algae.—SCIENCE.

DR. D. T. MACDOUGAL has been elected a foreign member of Hollandsche Matschappij van Wetenschappen, the Dutch Academy of Sciences.

PROFESSOR BRUCE FINK, the lichenologist, of Iowa College, has resigned to accept a professorship of biology in Miami University, Oxford, Ohio.

DR. FRIEDRICH CZAPEK, of Prague, has been appointed professor of botany and director of the botanic garden and institute of the University of Czernowitz.

PROFESSOR GEORGE MACLOSKIE, Princeton University, has retired from active service, having been appointed Professor Emeritus. He has been in charge of the botany of that institution since 1875.

BOTANICAL APPOINTMENTS confirmed recently by the trustees of the Ohio State University are as follows: ROBERT F. GRIGGS, assistant professor; FREDA DETMERS, instructor; and L. A. HAWKINS, fellow.

PROFESSOR CONWAY MACMILLAN has resigned the professorship of botany at the University of Minnesota and will devote his attention to business. The position is to be filled by promotion from the present staff.

PROFESSOR D. H. SCOTT'S presidential address before the Royal Microscopical Society, entitled "Life and Work of Bernard Renault," is published in Jour. Roy. Micr. Soc. **1906**: 129–145, with an excellent portrait.

HOWARD S. REED, instructor in botany at the University of Missouri, has resigned his position to accept an appointment in the Bureau of Soils, United States Department of Agriculture. H. L. SHANTZ has been appointed to succeed him.

THE EIGHTH annual session of the biological station of the University of Montana will be held at Flathead Lake from July 11 to August 16. This station combines the advantages of lake, plain, and mountain. Botany is in charge of THOMAS A. BONSER, of the Spokane high school.

HIS ASSOCIATES on the faculty of Brown University lately presented to Professor W. WHITMAN BAILEY a loving-cup, in token of their esteem for him personally and in commemoration of his twenty-nine years of active service, from which he retires this year. At a meeting of the trustees at Commencement he was appointed Professor Emeritus.

MRS. J. H. SCHAFFNER, of Columbus, Ohio, died recently after a brief illness. This is not only a sad loss of a devoted companion to Professor SCHAFFNER, but a botanist of promise and ability has passed away. Mrs. SCHAFFNER had published little, perhaps only one paper, over her own name, but a piece of completed cytological work will soon appear as a posthumous paper.

IN THE *Generalversammlungs-Heft* closing volume 23 of *Ber. Deutsch. Bot. Gesells.*, the following biographical sketches are published: WILHELM SCHWACKE, by TH. LOESENER; EDUARD TANGL, by G. HABERLANDT; JOHANN ANTON SCHMIDT, by E. PFITZER; OTTO WÜNSCHE, by J. ABROMEIT; FEDERICO DELPINO, by O. PENZIG; LÉO ERRERA (with portrait), by E. DE WILDEMAN.

AT THE REQUEST of some members of the American Medical Association Dr. HERMANN VON SCHRENK made a pathological exhibit at the recent meeting of this association in Boston. The exhibit showed types of some diseases of plants and some of the conditions producing these diseases. The manner of infection and spread of disease, the symptoms and causes, the methods of treatment and of investigation were illustrated. The time for securing the material was extremely limited, but nevertheless the exhibit occasioned much surprise to the medical men, though it showed but partially the work which plant pathologists have accomplished.

ERRATUM.—The date of publication of the June number was incorrectly given in the table of contents for the month, and in the list of dates of publication accompanying the title pages of the volume. On p. vi, line 23, for June 30 read July 7.